The

ENGINEERS' DIGEST

A World Review of

DESIGN & PRODUCTION · RESEARCH & DEVELOPMENT

VOL. XXII No. 10 OCTOBER, 1961

NEW

the first of the new range of FRASER MONO-RADIAL PUMPS

the new series SDS

Based on the proved Mono-Radial design of pumps, smaller in size but with new features giving increased output with improved performance.

PRESSURE RANGE—
up to 6,000 p.s.i.
SPEED—1,500 r.p.m.
MOUNTING—Flange or foot

FRASER

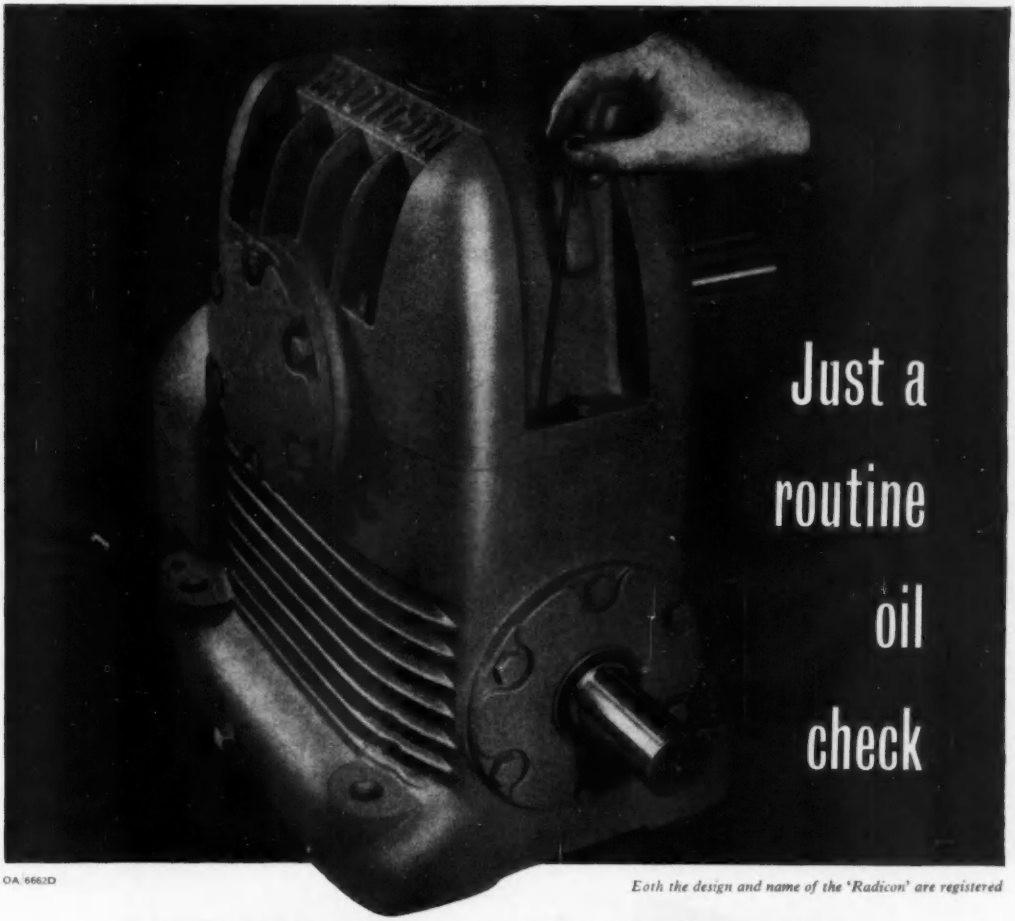
first & foremost in hydraulics

WRITE FOR ILLUSTRATED LEAFLET AND FULL TECHNICAL DETAILS

ANDREW FRASER & CO LTD

64-65 VINCENT SQUARE WESTMINSTER LONDON SW1 TEL: VICTORIA 6736/9

P.6667



OA 6662D

Both the design and name of the 'Radicon' are registered

RADICONS NEED NO OTHER ATTENTION!

Dependability. Isn't that what you want most of all from a speed reducer? The ability to run on and on and on—keeping peak efficiency with the minimum of maintenance. David Brown Radicons have that sort of reliability built in. It's been in the breed for over 60 years!

The new 'Solid Foot' Radicons are in that tradition. More, they now have improved mechanical and thermal ratings—meaning increased horsepower rating for size of unit. This range covers centres from 4" to 8" and drives up to 80 h.p. Larger models cover drives up to 300 h.p. For smaller drives the new 'Adaptable' range follows in the same tradition.

The Radicon Catalogue gives complete details of sizes, performance and selection of both types. Have you sent for your copy?

DAVID BROWN

An alliance of engineering specialists in gearing, machine tools, tools, castings, automobiles and agricultural tractors and machinery

THE DAVID BROWN CORPORATION (SALES) LIMITED

GEAR DIVISIONS · PARK WORKS · HUDDERSFIELD TELEPHONE 3500

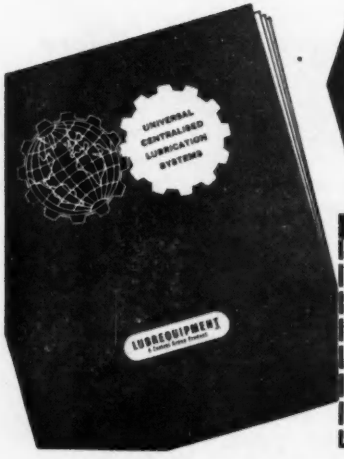
E.D.—1

A NEW UNIVERSAL LUBRICATION SYSTEM from CASTROL INDUSTRIAL

This new Universal Lubrication System represents the latest development in two-line centralised equipment. It is a typical product of the experience gained by the Castrol Group in nearly 60 years of designing precision lubricating equipment. This System is based on a new positive dispensing unit which can be operated in parallel, or progressively, or in any desired combination of both. It eliminates the drawbacks of parallel or progressive systems, yet combines the best features of both.

Castrol INDUSTRIAL OILS

This Universal System, which dispenses oil or grease, is particularly recommended for industrial machinery generally, from the largest and most complex to the small and simple types. Castrol Industrial engineers will be eager to recommend the most suitable ways for you to obtain the advantages of this new System in your type of plant. A telephone call involves you in no commitment and may well be the first move in putting all your lubrication worries behind you.



A new Castrol Industrial publication that should be in your file...

A new booklet entitled "Universal Centralised Lubrication Systems" is the latest publication in the Castrol Industrial series of technical manuals. It is very informative and profusely illustrated. Post the coupon today for your own copy.

POST THIS COUPON NOW

Please send my copy of "Universal Centralised Lubrication Systems" to:—

NAME .....

ADDRESS OF COMPANY .....

.....

POSITION HELD ..... E.D

Post coupon to: Castrol Industrial Ltd., Castrol House, Marylebone Road, London, N.W.1. Tel.: HUNter 4455

CONTENTS

	Page
The Minidigest	4
Contracts	10
Business Notes	14
Personal	18
News Round-up	22
New Technical Books	26
Latest Industrial Literature	28
The Blue Pages	81
The "Unified Transfer System" of Language Translation by Electronic Computers	89
The Theory of Combined Steam- and Gas-Turbine Installations	91
Flexible Insulated Electrical Conductors for High-Temperature Applications	95
Investigation into the Creep Behaviour of Unalloyed Titanium	97
The Ultrasonic Welding of Heat-Resistant Metals	101
The Fatigue Behaviour of Resistance Strain-Gauges	105
Methods of Generating and Heating Plasma	109
British Industrial Developments	117
Additional Abstracts	127
New Materials, Processes, and Equipment	131
Index of Advertisers	165

The ENGINEERS' DIGEST

A World Review of DESIGN & PRODUCTION · RESEARCH & DEVELOPMENT

VOL. XXII No. 10 OCTOBER, 1961

EDITORIAL AND ADVERTISING OFFICES:

GREAT BRITAIN
120 Wigmore Street, London, W.1.
Telephone: WELbeck 9357 & 6263

U.S.A.
366 Madison Avenue, New York 17, N.Y.
Telephone: MUrray Hill 2-8865

FRANCE
102 Rue Amelot, Paris (XI^e)
Telephone: VOL. 29-19

ITALY
Via degli Orombelli 13, Milan
Telephone: 23.62.457

Annual Subscription Rates:
£2 2s. 0d. in the Sterling area, $7.50 in the Dollar area

Printed in Gt. Britain by Williams, Lea & Co. Ltd. Clifton House, Worship Street, London, E.C.2. and published monthly by the proprietors, ENGINEERS' DIGEST LTD., 120 Wigmore Street, London, W.1.

FROM THE PITMAN TECHNICAL LIST

METALLURGY OF THE NON-FERROUS METALS
By W. H. Dennis, B.Sc., M.I.M. Second Edition. 75s. net.

TELEPHONY
Volume One—General Principles and Manual Exchange Systems
By J. Atkinson, M.I.E.E. 40s. net.

TELEPHONY
Volume Two—Automatic Exchange Systems
By J. Atkinson, M.I.E.E. 55s. net.

AIR COMPRESSORS
Control and Installation
By P. C. Bevis. 30s. net.

PRACTICAL SHEET AND PLATE METAL WORK
By the late E. A. Atkins. Sixth edition by W. A. Atkins, L.I.M., M.Inst.Met. 20s. net.

THEORY OF MACHINES
By Louis Toft, M.Sc., and A. T. J. Kersey, A.R.C.Sc. Sixth edition. 30s. net.

A GUIDE TO TECHNICAL WRITING
By C. Baker, A.R.Ae.S. 15s. net.

PITMAN, Parker St., Kingsway, London, W.C.2

The MINIDIGEST

Tests carried out in the U.S.A. by Aerojet-General indicate that the use of **molten metals as an aid to explosive-forming,** in place of the water commonly used, makes it possible to employ this forming method under elevated-temperature conditions with close control over the explosive pressures transmitted. Molten aluminium at 1800°F has been used as the forming bath for tungsten components and not only acts as the energy-transmission medium, but also as a heat-transfer medium. The process is as yet in the early development stages, but asymmetrical nozzle shapes have already been successfully formed in tungsten in this way.

* * *

A cutting tool utilizing the finest-grain tungsten carbide ever marketed has been developed in England by Hoy Carbides Ltd., of High Wycombe, Bucks., and is stated to have solved the problem of an **improved tungsten carbide cutting tip for machining heat-resistant alloys,** such as those used in aircraft engines, missiles, and reactor components. The new grade of carbide, which is a combination of fineness of grain with precision sintering and correct proportioning of alloys, is claimed to be able to machine the more difficult alloys at a greater speed and to produce a better finish and more components per regrind than any grade of carbide previously available.

* * *

A **new design of gas-filled, sealed, dry-type** transformer developed in the U.S.A. by General Electric utilizes perfluorpropane (C_3F_8) as the insulating and cooling medium. This gas is non-inflammable, non-explosive, and non-toxic, and will not decompose, even under extreme operating temperatures. Also, because of the superior insulating properties of perfluorpropane, the impulse levels of the new transformers, which are available in ratings of 300 kVA and above and 15kV and below, are higher than those of nitrogen-filled units. In addition, the transformers are smaller and lighter.

* * *

A new **ultrasonic grinding-wheel cleaner,** developed by the Cavitron Corporation, of Long Island City, N.Y., uses a magnetostrictive transducer to produce ultrasonic (20,000-cps) vibrations and a small aluminium tool-head attached to the end of the transducer. The tool-head is positioned just above the rotating

... and in an

will not hesitate

HALLMAC STOCK LIST

The foremost of its kind!

Send for your copy NOW!

SALES MANAGERS FOR THE

emergency HALLMAC TOOLS LIMITED

to make a special delivery anywhere!

A consignment may consist of anything from one to 100 or more items! HALLMAC branches plus HALLMAC representatives cover the entire country; and to ensure the goods reach you on time every means of transport is used, from general transport by road, rail, and air to Hallmac's own lorries and vans.

Engineers' Small Tools, Macrome Treated Tools, Hand and Power Tools—Hallmac carry in stock the most comprehensive range of proprietary brands in the United Kingdom. Each brand or make is carefully selected to ensure that all stock is of the highest quality, and the scope is enlarged still further by Hallmac's maintenance of 23,000 specifications in record form. This means that Hallmac can supply virtually *any* of your tool requirements, even "specials", ex-stock—"extra specials" may sometimes take a little longer.

Why not, therefore, confine ALL your tool-buying to a SINGLE reliable supply SOURCE, instead of dealing with many different suppliers of varying efficiency, wasting time on probably fruitless 'phone calls, and burdening your accounts department with an unnecessary number of accounts. The Hallmac service has already proved its worth to many leading industrial firms of international repute. Let us start proving it to you by sending you the latest 52-page Hallmac Stock List, acknowledged to be the finest in the trade!

HALLMAC TOOLS LIMITED

Head Office & Depot: P.O. Box 39, Macrome Road, Wolverhampton
Telephones: **52001** (5 *lines*) and **53015** (5 *lines*)

LONDON
Suite 413, English Electric House, Strand, London, W.C.2.
Telephone TEMple Bar **3950**

MANCHESTER
1 Lloyd Road, Manchester 19. *Telephone* Heaton Moor **3255**

GLASGOW
Central Chambers, 11 Bothwell Street, C.2. *Telephone* CENtral **5066**

HAND TOOL DIVISION OF THE BREN MANUFACTURING COMPANY

grinding wheel, delivering ultrasonic energy through a coolant, in which cavitation is produced. The reciprocating tool-head and cavitating coolant, coupled with the geometry of the structure and the rotating wheel, produce a very effective force field at the wheel surface to inhibit loading. It is claimed that tests have shown that the equipment confers a number of outstanding advantages, including extended wheel life, flatter work, finer surface finishes, and a minimum of burning and work deformation.

* * *

As reported in the *Review of the Electrical Communication Laboratory* (March-April 1961) of the Nippon Telegraph and Telephone Corporation, a study has been made in Japan of **chatter in switching relays,** with a view to establishing a method of designing chatter-free relays. For this purpose, the chatter arising between various vibratory systems and a rigid body has been investigated, and the relationships between chatter and vibratory constants have been clarified, as well as the conditions under which contact chatter ceases to occur. Based on the results of this investigation, a new type of contact spring, suitable for use in high-speed relays and ensuring chatter-free operation, has been developed.

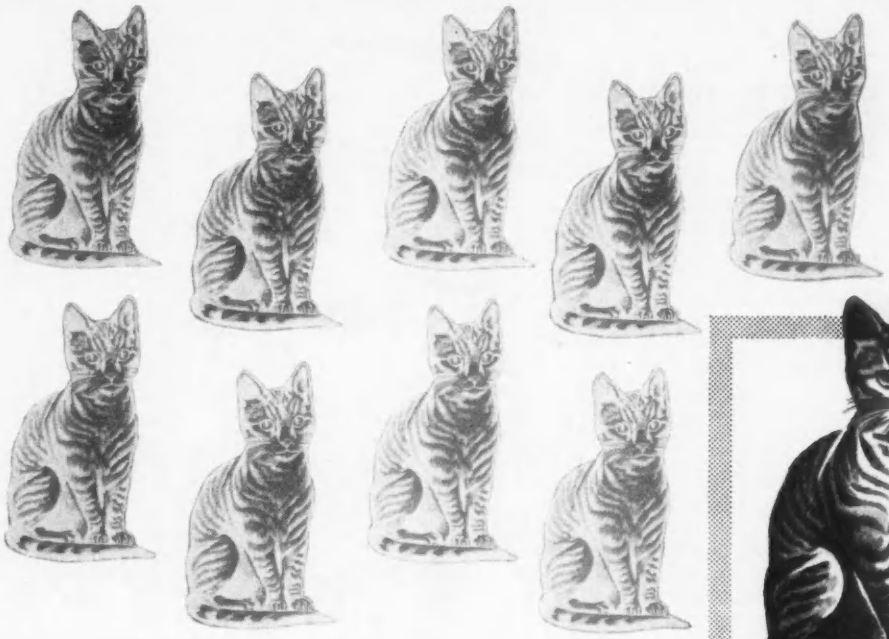
* * *

According to an article in *Giesserei* for August 24, 1961, a recently developed casting technique which utilizes a **vibrating ladle in the production of spheroidal-graphite and chill castings** makes it possible to decrease casting time and achieve a reduction in the use of desulphurizing agents. Two 3-ton pilot plants are already operating on this principle, and several others, with capacities from 2 to 10 tons, are being designed. In addition, it is proposed to investigate the possible advantages of this method in the production of copper and various light-alloy castings.

* * *

It is briefly reported in *Product Engineering* for July 31, 1961, that a high-density dispersion of alumina in an inert liquid can provide a high degree of thermal conductivity to aid **heat dissipation in electronic equipment.** For example, such a dispersion, inserted between a transistor and its case, can increase heat transfer by a factor of 2. The density of the alumina particles used

Balfour products include...



make certain of that with SUPER CAPITAL TOOL BITS

EXTRA LIFE

CAT'S WHISKER POINTS TO NOTICE :—

★ HIGH CARBON — HIGH VANADIUM — HIGH SPEED

★ EXTREME RESISTANCE TO ABRASION

★ FOR ROUGH AND FINISH TURNING OF TOUGHEST MATERIALS

★ PRODUCTION CONTROLLED AND TESTED IN BALFOUR'S OWN WORKS FROM THE MELT TO THE FINISHED PRODUCT

★ AVAILABLE IN SHEFFIELD, AND FROM BRANCH OFFICE STOCKS IN LONDON, BIRMINGHAM, MANCHESTER, GLASGOW AND CARDIFF

STEEL & TOOLS **ARTHUR BALFOUR** FOR THE WORLD

ARTHUR BALFOUR & CO. LTD. CAPITAL STEEL WORKS, SHEFFIELD, ENGLAND
ASSOCIATED COMPANY: THE EAGLE & GLOBE STEEL CO. LTD.

The MINIDIGEST

must be high enough to provide a conductive path through the liquid and must also, in effect, hold it together, preventing undue thermal expansion and permitting the dispersion to serve as a cushioning and vibration-damping medium. The particle size and shape must also be carefully chosen, two sizes being used—one large and one small—to fill the voids between the larger particles. A suitable inert fluid is polysiloxane, but others are under test and special means are being developed for mixing and metering the dispersion.

* * *

As described in the *Czechoslovak Journal of Physics* (No. 9, 1961), an improved **method of growing single crystals of zinc sulphide by sublimation** has certain definite advantages over conventional methods. In this method, a silica-glass tube with a charge of the original material arranged along a certain part of its length at the sealed end is placed in a furnace with the required temperature gradient, and, as soon as the growth of crystals starts, the tube is shifted out of the furnace at a suitable rate. In this way, it is claimed that, because fresh material is constantly supplied to the sublimation zone, the initial crystals are more uniformly activated. In addition, shifting of the growth zone in the tube ensures that the crystals do not grow on the polycrystalline substrate formed at the beginning but on the walls, with a decreased number of nuclei, and are spread over a larger section of the tube, so that they do not interfere with each other.

* * *

A method of radome construction incorporating an anti-icing system has been developed in the U.K. by Marston Excelsior Ltd. The system prevents the formation of ice on the outer surface of the radome, this being achieved by ducting hot air through channels between the inner and outer reinforced glass-fibre skins. The channels, which are of triangular shape, are formed in an expanded-rubber core and are lined with a thin glass-cloth laminate to provide additional strength. A special pattern has been evolved, permitting the use of channels of constant cross-section, so as to achieve adequate mechanical strength over the entire surface of the radome. It is considered that this method of construction, which has been patented, is also applicable to cooling radomes subjected to high kinetic heating.

THE FACTORIES ACT
1959: Section 12 (1)
and
Industrial Fire Safety
This folder has been specially prepared to make it easier for you to comply with the requirements of the above Act. It illustrates the types of equipment specified as suitable in the Ministry of Labour Leaflet No. 2019.
THE Pyrene COMPANY LIMITED

Thousands of these folders are already giving valuable aid to industry in the interest of Fire Safety.

WRITE FOR YOUR FREE COPY NOW !
(no obligation) to Dept. E.D.10.

THE PYRENE COMPANY LTD

9 GROSVENOR GARDENS, LONDON, S.W.1. *Tel.*: VICtoria 8474
Head Office & Works : BRENTFORD, MIDDX.

Canadian Plant : TORONTO *Australian Plant:* MELBOURNE

U.K.A.E.A use Saturn surge injectors

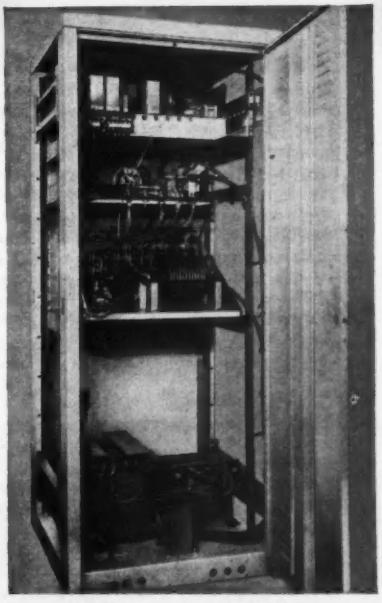
The manipulating machinery was provided by Vickers Armstrongs (Aircraft) Ltd. who also carried out the work of installation at the U.K.A.E.A. establishment.

Only the best is good enough for the U.K.A.E.A. After years of experience in the welding of light alloys, they still choose the Saturn Surge Injector for welding of the highest quality.

The illustration above shows two large five-bay consoles. On the right is an interior view of a part-assembled bay containing a Saturn Surge Injector. This equipment formed part of a recent U.K.A.E.A. installation for conducting, automatically, four simultaneous welding operations on each of two machines. The assembly incorporates many special features to meet the strict requirements of the U.K.A.E.A.

Of course not all welding jobs require such comprehensive installations. The standard models of the Saturn Surge Injector are well suited for use with less elaborate machine welding 'set-ups'.

If you are concerned in any way with the joining of aluminium you should be familiar with the outstanding potentialities of the Saturn Surge Injector. Write for further information and technical advice to:



Photographs reproduced by permission of U.K.A.E.A.

SATURN

SATURN INDUSTRIAL GASES LIMITED.
'Erl Wood', Windlesham, Surrey
Telephone: Bagshot 2441

Branches: SOUTHALL. GLASGOW. ALDRIDGE. MANCHESTER. SHEFFIELD. LYMINGTON. SUNDERLAND. THORNABY-ON-TEES

CONTRACTS

An order, worth more than £250,000, has been received by Associated Electrical Industries Ltd. from the Scottish Division of the National Coal Board for a fully integrated data-processing system incorporating the AEI 1010 digital computer. This computer, which is stated to be the fastest of its kind available, will handle the wage and salary data of about 90,000 people in 132 collieries, 22 brickworks, and other establishments. It will also undertake materials and supplies accounting, involving the costing and processing of 14,600 stores items per day, and will record the despatch of 4500 loads of coal per day. As there are some 1200 different qualities of coal, this latter task is obviously a complicated one. As a by-product of its normal programme, the computer will automatically provide any required statistics for marketing, finance control, and other purposes. From the results of these basic operations, completely integrated accounting for the whole Scottish Division will be developed. The equipment will be installed by the end of 1962.

* * *

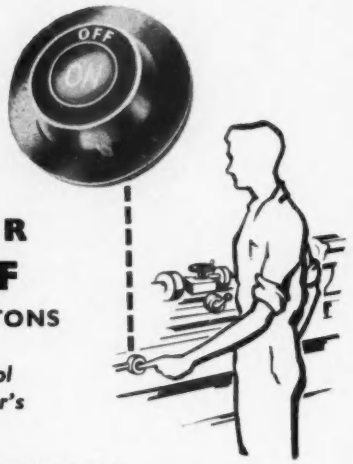
A contract has been awarded to Automatic Control Engineering, of London, S.W.6, by the Ministry of Works for mechanical and electrical services in connection with the instrumentation of No. 3 test-cell and other units at the National Gas Turbine Establishment, Pyestock, Hampshire. The contract is on a day-work basis, running for one year from May 1961, and is worth approximately £70,000.

* * *

The Head Wrightson Machine Co. Ltd., of Middlesbrough, a subsidiary of Head Wrightson & Co. Ltd., have received an order, valued at about £100,000, from the large Finnish metalliferous mining and copper-producing company Outokumpu Oy., of Pori, for the supply of a large tube drawbench to be used in the manufacture of non-ferrous tubes. The bench will be of the single-chain, triple-draw type, with a maximum pull of 100,000 lb and capable of drawing tubes up to 150 ft in length. Special electrical equipment will be provided to give infinitely variable drawing speeds up to a maximum of 300 fpm. This drawbench is arranged for semi-automatic operation and will incorporate a number of special features developed over recent years to enable high rates of production to be achieved with one operator.

* * *

The largest generator transformers in the world are to be manufactured by Ferranti Ltd. as a result of an order from the Central Electricity Generating Board for four 570-MVA, 3-phase 22/430-kV delta-star-connected, 50-cps, double-wound generator transformers. These units, whose value exceeds £1,000,000, will be installed in the world's largest coal-fired power station at West Burton, Notts., and will connect four 500-MW turbo-generators to the supergrid. Ferranti high-speed resistor transition on-load tap-changing gear will be fitted to cater for voltage variations of ±10% in eighteen steps. Cooling will be effected by means of forced-oil circulation through oil/water heat exchangers. The cores of the 570-MVA



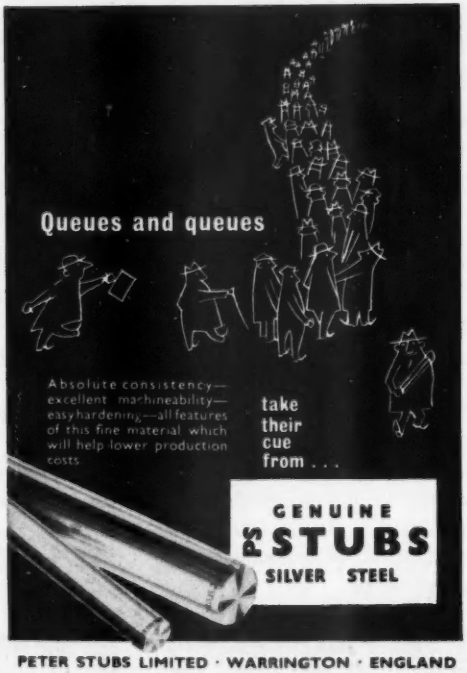
SLEEPER
ON/OFF
PUSH BUTTONS

put safe control at the operator's finger tips.

The unique **Sleeper ON/OFF Push Button** provides positive **ON/OFF** control at the working plane — **safely — conveniently**

Other **SLEEPER** *products include:*
- **FLOAT SWITCHES**
- **LIMIT SWITCHES**

C. E. SLEEPER LTD.,
PONSFORD ROAD WORKS, MINEHEAD, SOMERSET
Telephone: Minehead 873


Queues and queues
Absolute consistency—excellent machineability—easy hardening,—all features of this fine material which will help lower production costs
take their cue from . . .
GENUINE
STUBS
SILVER STEEL

PETER STUBS LIMITED · WARRINGTON · ENGLAND
SS38

A diamon is for HARDNESS

The pyramid diamond indenter makes its mark; its 'diamond' impression is accurately measured to knife edges in the micrometer ocular; the 'VPN' reading shows immediately on a special digit counter.

With the VICKERS PYRAMID HARDNESS TESTER all classes of work—finished components, thin sheets, the hardest of heat-treated steels and alloys—can be conveniently tested at the place of production with laboratory accuracy. And readings of course are given in the internationally recognised Vickers Pyramid Numerals VPN—*world standard of hardness determination.*

VICKERS

VICKERS-ARMSTRONGS (ENGINEERS) LIMITED 13 CITY ROAD LONDON ECI
Tel MET 8877 *'Grams* VICKSBOX AVE LONDON

TGA CH979

CONTRACTS

units will be of minimum-bolted, five-limb backbone construction, employing a full 45-deg. mitring of all joints, so as to ensure minimum core loss and magnetizing current. The five-limb core construction will be used to bring the units within permissible loading gauges, and the core clamps and tanks will be of aluminium to bring down the weight within transport restrictions. The weight of each complete transformer, stripped for transport, will be kept down to 215 tons, the dimensions being 32 ft 6 in. × 13 ft 6 in. × 16 ft 2 in. high.

* * *

The Power-Gas Corporation Ltd., a member of the Davy-Ashmore Group, have been appointed engineering contractors for the building of a complete ammonia plant at Grenaa in Denmark. This plant forms part of a new fertilizer factory for Dansk-Norsk Kvaelstoffabrik, of Copenhagen. The value of the completed plant will be nearly £2,000,000, and Power-Gas will be responsible for the design, procurement, erection, and commissioning.

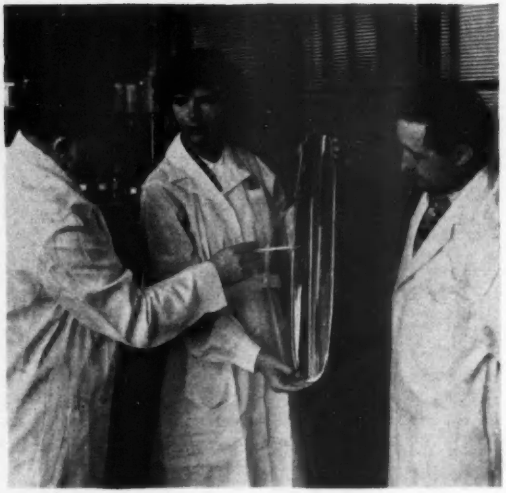
* * *

An order, valued at about £1,300,000, for sixteen diesel-electric locomotives has been awarded to The English Electric Co. Ltd., by Rhodesia Railways. The locomotives, each of 1875 hp, are similar to 35 already supplied by the company, and are designed for a gauge of 3 ft 6 in. They will run on a track having gradients and curves, combined with high altitude and ambient temperatures, resulting in onerous operating conditions. Similar locomotives have already been supplied to the East African Railways and Harbours. The Vulcan Foundry Ltd. and Robert Stephenson & Hawthorns Ltd. (both members of The English Electric Group), and the Preston Works of English Electric will collaborate in the manufacture of these locomotives.

* * *

A contract, valued at £300,000, for the design and installation of refinery-gas reforming plant at Granton, Edinburgh, has been awarded to Humphreys and Glasgow Ltd., of London, by the Scottish Gas Board. The plant, which is of the Onia-Gegi self-steaming type, producing sufficient waste-heat steam for process use, will comprise two units for reforming refinery gas, with a maximum production output of 18,000,000 cubic feet per day of 450-BTU town gas. The plant will also be capable of reforming butane, if required. Design work has already commenced, and it is expected that the contract, which includes civil engineering, as well as design, supply, and erection, will be completed in a little over one year. The Onia-Gegi cyclic process was originally developed in France by l'Office National Industriel de l'Azote (ONIA) and was further developed by the Humphreys & Glasgow associate company, Société de Construction d'Appareils pour Gaz à l'Eau et Gas Industriels (GEGI). The new plant, which features a single reactor vessel that can later be modified for light-distillate reforming, will be the first of the Onia-Gegi type to be built in Scotland, though no less than 213 plants of this type have so far been built throughout the world by Humphreys & Glasgow or their French associates.

ANODISING



TECHNICAL CONTROL

FINER, BRIGHTER FINISHES are ensured by the advanced techniques developed by our laboratory staff. Frequently, improved production at less cost can be effected through A & A experience. As Pioneers of Anodising in this country, we have established many standard specifications. We can also work to specifications of large manufacturing organisations. At A & A we have all the facilities and specialised equipment to guarantee your finishing requirements are fulfilled in every technical aspect. When it comes to finishing it will pay you to consult A & A **first!**

ALUMILITE & ALZAK LTD

anodising specialists for over 30 years

PRIORY WORKS · Dept. N · STATION ROAD, LONDON, S.W.19
Tel.: LIBerty 7641
MIDLANDS: 20-21 MERIDEN STREET, B'HAM 5 Tel.: MIDLAND 7426

.....TIME

after **TIME**

after **TIME**

after **TIME**

after **TIME....**

....IT WORKS!

(NO BHI PROXIMITY LIMIT SWITCH HAS EVER FAILED)

When the two parts of the BHI Proximity Limit Switch attain their critical distance, nothing moves, no electrical contact is made. There's nothing to wear or stick, pit or corrode, nothing to get out of adjustment, no fatigue, no burn-outs. And because the sensing part is sealed, it'll work in oily dirty corrosive conditions — in fact, almost anywhere.

About 68% of electrical stoppages of plant are caused by limit switch failure; but no BHI proximity limit switch has ever failed. Could you do with a switch that works for a lifetime?

Switches are offered to work at $\frac{1}{4}$", $\frac{1}{2}$" and $2\frac{1}{2}$" proximity. The BHI "package equipment", standardised for applications with up to 20 limit switches, comprises a power unit (fed from your 380-440V a.c. supply) and signal conversion panels, on which each limit switch operates an electromechanical relay, all in one enclosed cubicle.

Write for full details and price list.

BHI

Metal Industries Group

BROOKHIRST IGRANIC

Enquiries to :-

NORTHGATE WORKS . CHESTER

MAKERS OF BRITAIN'S WIDEST RANGE OF ELECTRICAL CONTROLS AND ASSOCIATED EQUIPMENT

BI/53

BUSINESS NOTES

A new company, **Jamesbury-Serck Ltd.**, of Eastern Avenue, Gloucester (Tel: Gloucester 21451), has been formed by **Serck Ltd.**, of Birmingham, and the **Jamesbury Corporation**, of Worcester, Mass., to manufacture and market the Jamesbury "Double Seal" ball valve on a world-wide basis.

* * *

A licence agreement has been signed between **Dowty Hydraulic Units Ltd.**, of Ashchurch, Gloucester, and the **Kayaba Industry Co. Ltd.**, of Tokyo, for the manufacture in Japan of Dowty hydraulic gear pumps and motors. Production will commence immediately, the countries for which exclusive selling rights have been granted including Japan, Formosa, Korea, and Indonesia.

* * *

It is announced that **Établissements Kuhlmann**, of Paris, and **E. I. du Pont de Nemours & Co.**, of Wilmington, Delaware, U.S.A., will form a new French company, to be called **Dekachimie**, who will manufacture and sell isocyanates, a basic raw material used in the production of urethane foams. Each of the two companies will own 50% of the stock of the new company, capitalization amounting to 30,000,000 new French francs. Dekachimie will build a plant near Lille at the existing La Madeleine facility of Établissements Kuhlmann, completion of the plant being scheduled for 1963. In the meantime, isocyanates from the U.S.A. will continue to be sold in the European market by the new company.

* * *

Associated Electrical Industries Ltd. and **Enfield Cables Ltd.** have transferred all their business in connection with paper-insulated and polythene-insulated telephone cables, as well as coaxial and other high-grade cables for telecommunications, to **Telephone Cables Ltd.**, of Chequers Lane, Dagenham, Essex. Telephone Cables Ltd., formed in January 1961 and jointly owned by AEI and Enfield Cables, is now handling all home and export business in this field for both companies.

* * *

A new factory and offices have recently been opened by **Avdel Ltd.**, specialists in high-speed fastening systems, at Welwyn Garden City, Herts. The new factory, which is a single-storey building of modern design, will enable the whole production to be under one roof. The head office will be housed in the new office block, which is a two-storey building, also of modern design.

* * *

Following a recent agreement, **G. & J. Weir, Ltd.**, of Glasgow, S.4, have taken up a licence to manufacture and market in the U.K. the range of pumps made by **Pacific Pumps Inc.**, a subsidiary of **Dresser Industries Inc.**, of Los Angeles, Cal. This range of pumps covers a wide variety of applications in the petroleum, petro-chemical, and allied industries and is already well established in the U.K. With the addition of these units to their existing products, Weir are in a position to operate in markets which they have not previously covered. Selling arrangements for "Weir-Pacific" pumps will be handled by existing staff at the company's branch offices and at the Weir headquarters at Cathcart, Glasgow, but in the London area Mr. G. R. Murison, formerly manager of the Weir office in Birmingham, will take over Weir-Pacific sales from the Weir office at 37 Mincing Lane, London, E.C.3.

* * *

A new company, designated **Bedford Rock Drill Components Ltd.**, has been set up to produce for the first time in the U.K. carburized rods for rock drilling. The company will operate from a site adjacent to the main Lion Works of **John Bedford & Sons**, the well-known Sheffield firm of steel manufacturers, and the two companies will work in close association. The carburizing process, which requires highly specialized furnaces of unusual design and considerable skill in the application of case-hardening techniques, is being undertaken by Bedford under licence from the **Gardner-Denver Company**, of Quincy, Ill., and Denver, Col., who are pioneers in the development of carburized rock-drilling equipment.

* * *

In conjunction with the **Lease Plan International Corporation**, of New York, a new company has been formed by **Hambros Bank Ltd.**, the **Phoenix Assurance Co. Ltd.**, and **Cable & Wireless (Holding) Ltd.** to specialize in the large-scale leasing of capital equipment and vehicles to British industry and other commercial undertakings. The new company, called the **Equipment Leasing Co. Ltd. (ELCO)**, is designed to facilitate the purchase of new plant and equipment by employing the "pay-as-you-use" technique which has been so successful

CHAPMAN & HALL

The Mathematical Theory of Linear Systems

BY B. M. BROWN, M.A.

Assistant Professor of Mathematics
Royal Naval College, Greenwich

This second volume in the Automation and Control Engineering Series not only gives a comprehensive introduction to the theory of linear equations and their applications to control systems, but is intended to provide the necessary mathematical background to other subjects in the Series. *Illus. 50s.*

★

A NEW REINHOLD BOOK

Plastics in Nuclear Engineering

BY J. O. TURNER

This latest addition to Reinhold Publishing Corporation's well-known *Plastics Applications Series* provides a complete coverage of the working role of plastics in nuclear science and technology.
Illus. 44s.

37 ESSEX STREET, LONDON, W.C.2.

I agree... for speed and long life

order Eclipse

Made by James Neill & Co. (Sheffield) Ltd., and obtainable from all tool distributors

UH52

BUSINESS NOTES

in the U.S.A. during the past few years. Substantial finances will be available from the initial subscribers and from many other sources. The company will initially concentrate on finance leasing, but may well extend its activities later. From American experience, it is stated that the most usual items for leasing are machine tools and other types of factory equipment; electronic equipment; fleets of cars, vans, and lorries; office machines; storage tanks; containers; and chemical process equipment. There is however, no real limitation, and leasing can range from jet aircraft to ships and from electric drills to full equipped industrial plant.

* * *

The Automation Unit of **AEI/Davy-United Steelworks,** formed in 1960 to apply automation to the processing of steel and non-ferrous metals, will from now on trade in its own right, the interests of **Associated Electrical Industries Ltd.** and of **Davy-Ashmore Ltd.** in this field having been combined in a jointly owned company, **Davy-AEI Automation Ltd.,** with headquarters at Booths Hall, Knutsford, Cheshire. The chairman of the new company is Mr. M. A. Fiennes, managing director of Davy-Ashmore Ltd., and the vice-chairman is Mr. C. R. Wheeler, vice-chairman of Associated Electrical Industries Ltd.

* * *

It is announced by **Associated Commercial Vehicles Ltd.** that their main subsidiary company, **A.E.C. Ltd.,** has entered into an agreement, subject to the approval of the Argentine Government, with **SIAM Di Tella Automotores S.A.** to manufacture passenger and goods vehicles under licence in Argentina. SIAM Di Tella Automotores S.A., who make B.M.C. 1½-litre vehicles and Lambretta scooters under licence, are a subsidiary company of **SIAM Di Tella Ltda.,** the largest industrial group in Argentina.

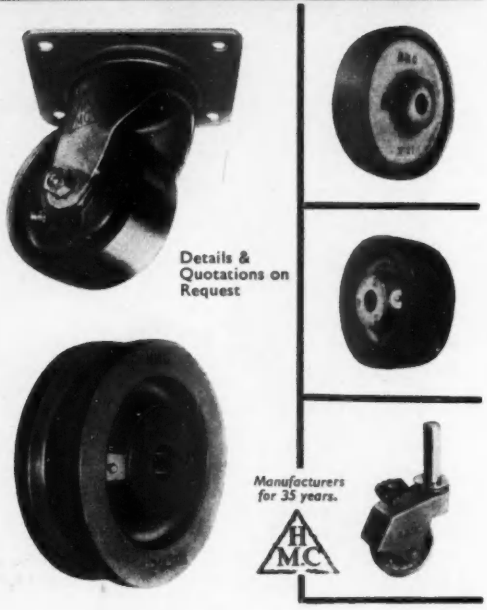
* * *

A sale-purchase agreement has been concluded between **Acheson Industries (Europe) Ltd.,** of London, E.C.2, and **Cabot Carbon Ltd.,** of Stanlow, Ellesmere Port, Cheshire, enabling the latter company to purchase the business and manufacturing facilities of the Dispersed Pigments Division of Acheson Industries (Europe) Ltd. at Dukinfield, Cheshire. This transaction is part of a larger agreement whereby the **Cabot Corporation,** of Boston, Mass., acquire the business and manufacturing facilities of the **Acheson Dispersed Pigments Company,** of Philadelphia, Pa. The agreement relates only to the dispersed-pigments operations of the Acheson organization and in no way affects those units in the U.S.A. and Europe engaged in the production of dispersions of colloidal graphite and other solids.

* * *

To meet the increasing volume of orders and to permit further expansion of their business in connection with fractional-horsepower motors, **Evershed and Vignoles Ltd.,** of Acton Lane, London, W.4., have established a new division at Devonshire Works, Dukes Avenue, Chiswick.

WHEELS & CASTORS FOR INDUSTRY



LARGE STOCKS ALWAYS IN HAND

ENSURE PROMPT DESPATCH

WHEELS

Rubber Tyred Roller Bearing · Rubber Tyred Plain Bearing · Rubber Tyred Heavy Duty · Cast Iron Roller Bearing · Cast Iron Plain Bearing · Cast Iron Heavy Duty · Solid Rubber · Single Flanged Double Flanged

CASTORS

Medium Duty · Heavy Duty · Twin Wheel · Pressed Steel · **All with various types of fittings.**

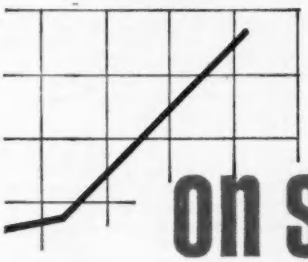
Send for ILLUSTRATED CATALOGUE

H.M.C. WHEELS, LTD.

75 HIGH STREET, HORNSEY, N.8.

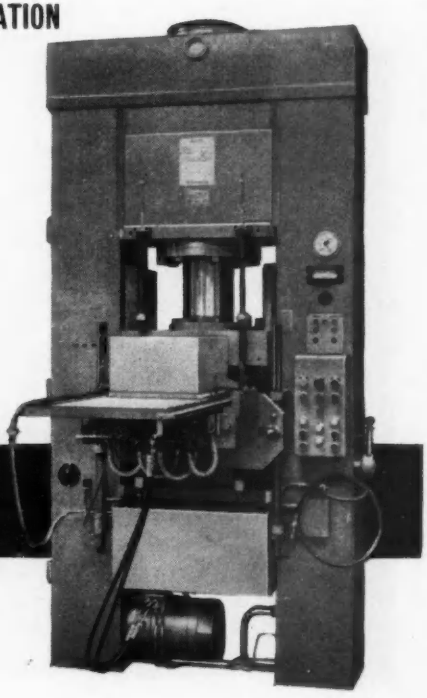
Telephone: MOUntview 7666

Higher production AUTOMATICALLY on short runs too!



BIPEL Quick Tool Change and TROUBLE-FREE OPERATION Bring LONG RUN AUTOMATION & ECONOMY to SHORT RUN COMPRESSION JOBS . . .

BIPEL fully automatic compression presses open up entirely new possibilities for the smaller as well as the larger moulding shop because rapid changes can be made from one product to another. Continuous, reliable operation with simple regular maintenance ensures increased productivity and low rejects with reduced overheads. Many products, especially electrical components, can be moulded continuously without attention and BIPEL automatic stripping also extends to tube caps and other threaded mouldings. BIPEL automation is *your* answer to quality/price demands.



BIPEL FULLY AUTOMATIC POWDER OR PELLET LOADING PRESSES WITH TOP OR BOTTOM EJECTION

Both powder and pellet loading presses are available with transfer equipment as an optional extra for semi-automatic working. Standard bolsters with induction heating are offered. Impressions can be changed without removing the bolster in as little as 15 minutes. BIPEL will gladly advice on the suitability of any moulding for fully automatic working. Where required, a complete set-up of tool and press can be supplied.

BIPEL Fully Automatic Presses

"Progress with Precision"

B.I.P. ENGINEERING LIMITED

STREETLY WORKS · SUTTON COLDFIELD · Tel: Streetly 2411 · Telex: 33541

B·I·P

PERSONAL

Mr. T. P. Barlow, works manager of the Oil-Engine Division of Rolls-Royce, has been appointed a director of the Division.

* * *

It is announced by Alfred Herbert Ltd., of Coventry, that **Mr. B. C. Harrison, M.I.Mech.E., M.I.P.E.,** has been elected deputy managing director of the company. **Mr. J. W. Ellson, F.C.I.S.,** has decided to retire from the board at his own request after 42 years of service but, at the request of the chairman of the company, **Colonel C. W. Clark,** has agreed to undertake lighter duties, so that his long and valuable experience will still be available to the company. **Mr. A. E. Smith F.C.A.,** has been appointed to the board as deputy financial director.

* * *

The United Steel Companies Ltd. announce that **Mr. N. D. Macdonald,** general works manager of their Workington Iron and Steel Company branch, has been appointed a director of this branch.

* * *

Mr. R. K. Pridham, Southern Area Manager, and **Mr. P. W. Gudgeon,** Northern Area Manager, have both been appointed to the board of Monks & Crane Ltd., of Birmingham.

* * *

It is announced that **Mr. G. C. S. Greenhead, F.C.I.S., M.B.I.M.,** who joined Parkinson Cowan Ltd. two years ago as general manager (administration), has now been appointed to the board of directors.

* * *

Mr. D. E. Haynes, formerly secretary of Hawker Siddeley Aviation Ltd., of Kingston, has been appointed secretary of Bristol Siddeley Engines Ltd. He succeeds **Mr. F. Shutt,** who has been secretary since April 1959, and who has taken up an appointment as financial comptroller of Hawker Siddeley Industries Ltd.

* * *

The British Hoist & Crane Co. Ltd., of Compton, Berks., announce that **Mr. D. L. O. Lloyd** has been appointed crane sales manager. Mr. Lloyd will be based at the London depot of the company and will be responsible for mobile-crane sales throughout Great Britain.

* * *

Mr. F. T. Jones, A.M.I.Prod.E., has been appointed a director, and **Mr. J. A. Grace** commercial director, of Microcell Ltd., of London, W.C.2, a subsidiary of BTR Industries Ltd.

* * *

It is announced by The British Electrical & Allied Manufacturers' Association (BEAMA) that **Mr. L. H. Short, M.C.,** director of overseas operations of The English Electric Co. Ltd., has been elected chairman of the Export Panel of the Association. This panel,

An invitation to subscribe to this Important New Pergamon Journal

International Journal of

MACHINE TOOL DESIGN & RESEARCH

This important and authoritative new international research Journal is devoted to the rapid publication of papers dealing with design, development and research relating to the field of machine tools, including such topics as metal cutting and forming processes, relevant plasticity and other problems, tool wear, machine tool vibration, machine tool elements, mechanical engineering aspects and machine tool control etc. The Journal publishes experimental and theoretical work as well as work of a technical nature on designing and manufacturing problems that are original and of potential value to the machine tool industry. The papers appearing will deal with investigations or results not yet published elsewhere. However, review papers or translations of important publications, in particular from Germany and the U.S.S.R., will also be included from time to time.

CONTENTS OF VOL. 1 Nos. 1 & 2

S. A. TOBIAS: Machine Tool Vibration Research; F. KOENIGSBERGER and A. J. P. SABBERWAL: An Investigation into Cutting Force Pulsations during Milling Operations; L. R. BAKER: Possible Applications of the S.I.R.A. Position-Sensitive Photocell to Machine Tool Control; W. A. HAGGERTY: Effect of Point Geometry and Dimensional Symmetry on Drill Performance; W. S. HOLLIS: The Application and Effect of Controlled Atmospheres in the Machining of Metals; M. EUGENE MERCHANT: Recent Progress in Metal Removal Research at Cincinnati; P. L. B. OXLEY: Mechanics of Metal Cutting; J. K. ROYLE and A. COWLEY: The Design of a High Performance Position Control System for Machine Tool Profiling Operations; T. M. BIRCHALL, F. A. LEWIS and R. W. NEW: Application of Research Results in Machine Tool Design and Development; J. P. GURNEY and S. A. TOBIAS: A Graphical Method for the Determination of The Dynamic Stability of Machine Tools; G. M. BROWN: The Dynamic Characteristics of a Hydrostatic Thrust Bearing.

JOINT EDITORS-IN-CHIEF

PROFESSOR S. A. TOBIAS, Department of Mechanical Engineering, Birmingham University;

DR. F. KOENIGSBERGER, Department of Mechanical Engineering, Manchester College of Science and Technology.

Assisted by an International Board of Editors.
To be published Quarterly.

Annual Subscription rates: Rate "A" 10 gns. ($30.00): To libraries, university departments, government laboratories, institutions and other multiple reader organisations.

Rate " B " 3 gns. ($10.00): To private individuals who order direct from the publishers certifying that the journal is for their personal use only.

PERGAMON PRESS

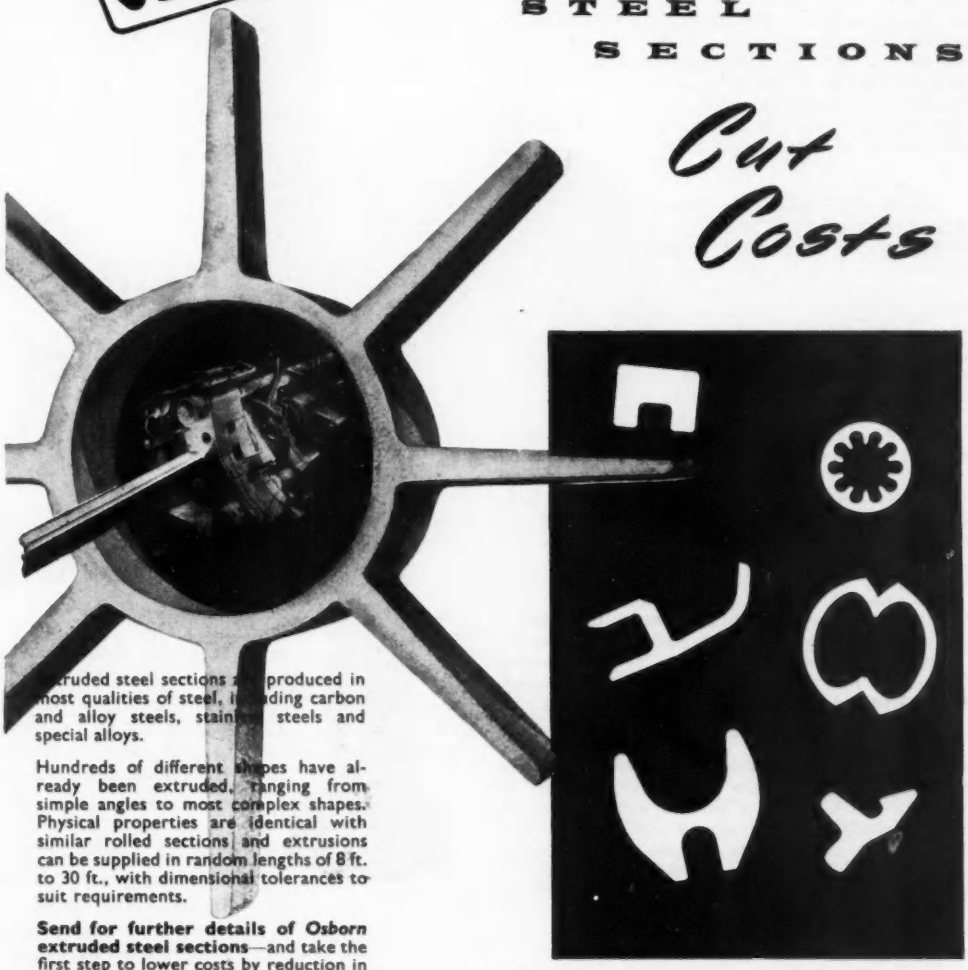
OXFORD · LONDON · NEW YORK

Headington Hill Hall, Oxford 4 & 5 Fitzroy Square, London, W.1
122 East 55th Street, New York 22, N.Y.

OSBORN

EXTRUDED
STEEL
SECTIONS

Cut Costs



...truded steel sections ... produced in ...most qualities of steel, i... ...ding carbon and alloy steels, stain... steels and special alloys.

Hundreds of different shapes have already been extruded, ranging from simple angles to most complex shapes. Physical properties are identical with similar rolled sections and extrusions can be supplied in random lengths of 8 ft. to 30 ft., with dimensional tolerances to suit requirements.

Send for further details of *Osborn* extruded steel sections—and take the first step to lower costs by reduction in machining and elimination of scrap.

Steelmakers · Steelfounders · Engineers' Toolmakers

PERSONAL

comprising leading specialists in the electrical industry on export matters, is the chief advisory body to the BEAMA Council on overseas trade. Mr. Short was vice-chairman of the panel during the past two years and succeeds **Mr. E. V. Small,** consultant to Associated Electrical Industries Export Ltd., who was chairman for this period. The new vice-chairman is **Mr. H. P. Martin,** sales director of C. A. Parsons & Co. Ltd.

* * *

Mr. W. C. Vickers, B.Sc. (Mech.Eng.), who joined Ruston & Hornsby Ltd., of Lincoln, in the early days of their gas-turbine development and became chief engineer, gas turbines, in 1956, has rejoined the company as engineering manager, Turbo-Machinery and Allied Products Division. For the past two years or so, Mr. Vickers has been with Brown Boveri, of Baden, Switzerland, on research and development work on centrifugal and axial compressors.

* * *

Mr. H. J. Wenban has relinquished his position as managing director of the Forgrove Machinery Co. Ltd., of Leeds, one of the Baker Perkins group of companies, and has been succeeded in this position by **Mr. W. A. B. Brown.** Mr. Wenban will, however, continue to act as chairman of the board.

* * *

Rotherham & Sons Ltd., of Coventry, announce that **Mr. W. L. G. Nicoll** has been appointed to the board of the company as sales director. In addition to Mr. Nicoll, the board now comprises **Mr. F. D. O'Brien Newman** (chairman), **Mr. R. G. Benham** (general manager), **Mr. C. J. Mason, F.C.A.,** and **Mr. J. F. Carey** (secretary).

* * *

Mr. F. T. Bagnall, who recently retired from the position of electric-furnace melting-shop manager of Samuel Fox & Co. Ltd., of Sheffield, and who put into operation the first large arc furnaces in the U.K., has now made his services available exclusively to Birlec-Efco (Melting) Ltd., of Westgate, Aldridge, Staffs., and will help in the design and operation of all equipment manufactured by Birlec-Efco.

* * *

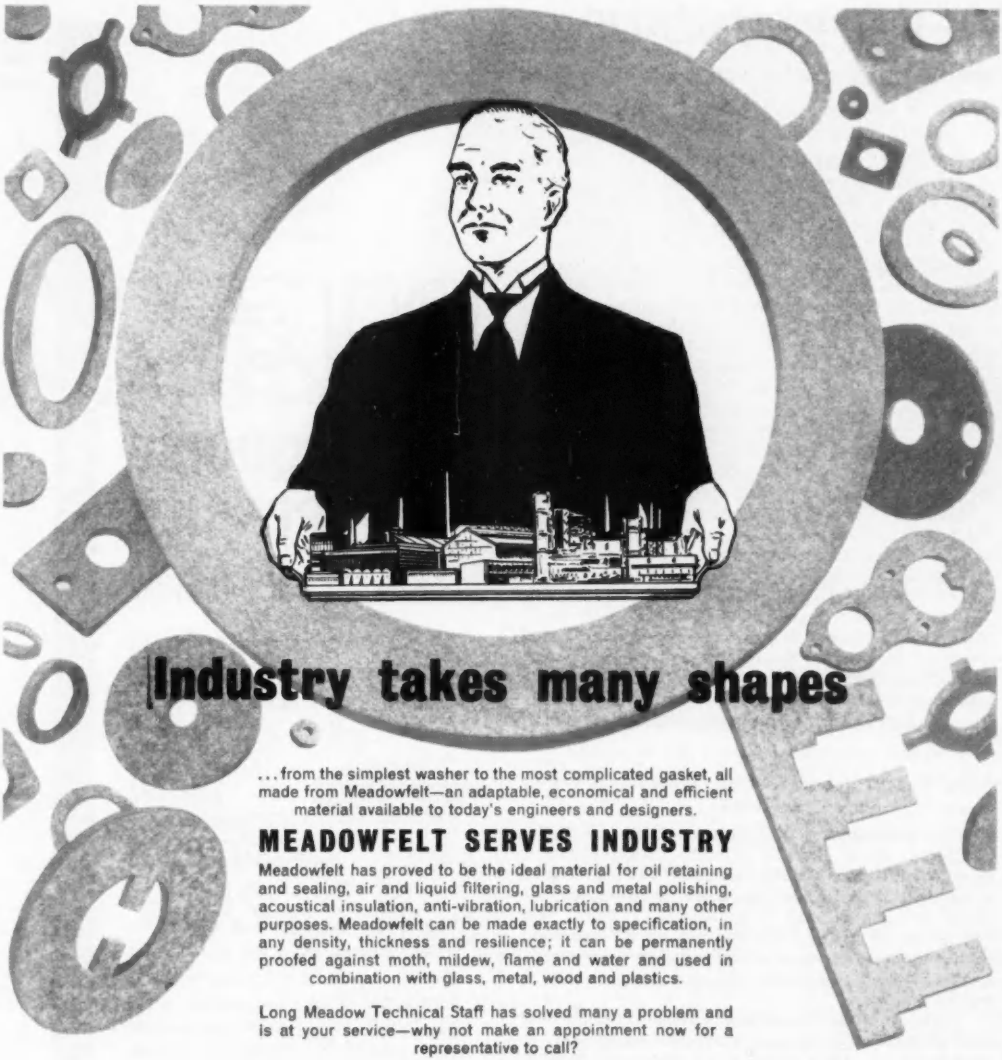
Mr. D. Parry Davies has been appointed a director of Mond Nickel (Retirement System) Trustees Ltd., and is succeeded as comptroller of The International Nickel Co. (Mond) Ltd. and Henry Wiggin and Co. Ltd. by **Mr. L. C. H. Voss. Mr. C. W. R. Edwards** has been appointed secretary of The International Nickel Co. (Mond) Ltd. and Henry Wiggin & Co. Ltd. in succession to **Mr. E. Vaughan.** Mr. Vaughan remains a director of both companies. **Mr. A. C. Sturney** has been elected to the board of The International Nickel Co. (Mond) Ltd., relinquishing his appointment as general manager of publicity. He is succeeded as general manager of publicity by **Mr. L. F. Denaro,** who relinquishes his appointment as assistant to the managing director.

Cold Headed Bolts and Set Screws

Why look elsewhere, when all the benefits of long specialization plus the closest adherence to exacting quality standards are so conveniently available. Let ORMOND quote for all Repetition Parts—for single and multi spindle automatics up to 1¼" diameter; Brass, Steel and Light Alloy Screws in Rolled and Cut Threads, Grub screws, Nuts, Allthreads, Hexagon Bolts and Set screws turned from bar and Cold Headed Grades "A," "B" and High Tensile.

ORMOND ENGINEERING COMPANY LTD

THE ORMOND ENGINEERING Co. Ltd.
ORMOND HOUSE, ROSEBERY AVENUE, LONDON, E.C.1
Telephone: TERminus 2888 Telegrams: "Ormondengi, Cent."



Industry takes many shapes

...from the simplest washer to the most complicated gasket, all made from Meadowfelt—an adaptable, economical and efficient material available to today's engineers and designers.

MEADOWFELT SERVES INDUSTRY

Meadowfelt has proved to be the ideal material for oil retaining and sealing, air and liquid filtering, glass and metal polishing, acoustical insulation, anti-vibration, lubrication and many other purposes. Meadowfelt can be made exactly to specification, in any density, thickness and resilience; it can be permanently proofed against moth, mildew, flame and water and used in combination with glass, metal, wood and plastics.

Long Meadow Technical Staff has solved many a problem and is at your service—why not make an appointment now for a representative to call?

MEADOWFELT
REGISTERED

THE PRESSED FELT THAT DOES SO MANY JOBS SO WELL

LONG MEADOW FELT COMPANY LIMITED · KIDDERMINSTER · M. of A., W.O. & A.R.B. approved. *Telephone* 4071-2

NEWS ROUND-UP

Congress of the International Federation of Automatic Control

The second congress of the International Federation of Automatic Control (IFAC) will be held in Basle, Switzerland, in September 1963 at the invitation of the Swiss Association for Automatic Control. A committee of the British Conference on Automation and Computation (BCAC) will co-ordinate the submission of papers from the U.K. to the congress. Most of the papers will deal with the theory or application of automatic controls, while a number will also deal with the components of control devices. Subjects to be covered include the theory of discrete systems, optimal systems, learning systems, and systems reliability, process dynamics, computer studies of applications, and optimizing or adaptive control applications, as well as new and effective devices and measurement of the reliability of components.

Papers may be submitted in English, French, German, or Russian. The final version of any paper by a British author should be in the hands of the BCAC committee not later than June 1, 1962, for transmission during August 1962 to the International Selection Committee of IFAC, whose Executive Council has ruled that the number of papers must not exceed 100.

Offers of papers from the U.K. should be made to the Honorary Secretary, BCAC, c/o The Institution of Electrical Engineers, Savoy Place, London, W.C.2. General enquiries concerning the congress arrangements should be addressed to the Secretary of IFAC, Dr.-Ing. G. Ruppel, Prinz-George-Strasse 79, Düsseldorf, Germany.

Royal Charter for the British Institution of Radio Engineers

The Council of the British Institution of Radio Engineers, of 9 Bedford Square, London, W.C.1, announces that Her Majesty The Queen has been pleased to approve the grant of a Charter to the Institution, the Order in Council being dated August 2, 1961. This honour sets the seal on the achievements of the Institution during the past 36 years, the Institution having been founded in 1925 when radio engineering, as an industry, was in its infancy.

The grant of the Charter is in recognition of the vital role played by radio and electronic engineering in modern times. The Charter of the Institution specifies that its main object is to continue to advance the science and practice of radio and electronic engineering. The potential of this branch of science in communication and industrial aids provides great opportunity for the youngest of the British and Commonwealth Chartered bodies.

Computer System for Controlling Basic-Oxygen Steel-Furnace Plant

An order has been received by Thompson Ramo Wooldridge, Inc., of Los Angeles, Cal., from the Great Lakes Steel Division of the National Steel Corporation for a computer system to control the world's largest basic-oxygen steel-furnace plant in Detroit, Mich. As announced by International Systems Control, of Wembley, in whom Thompson Ramo Wooldridge and The General

NEW

TURQUOISE PENCILS

set a new standard for lead strength

The greatly increased lead strength of New Turquoise sets a new standard for drawing pencils. New Turquoise pencils hold a fine needle-point without snapping; save time by eliminating frequent re-sharpening—and money, too, through fewer replacements! And this *extra* lead strength means perfect 'originals' and cleaner, sharper reproductions every time. Crisper, clearer lines, preciser shadings—every detail exactly right with no omissions, ghost lines or fade-outs.

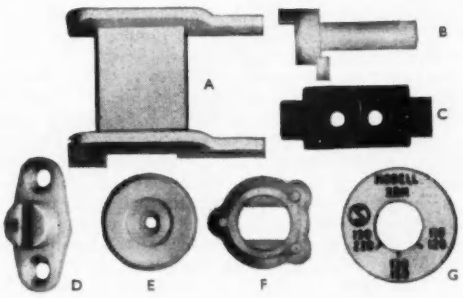
GRADING: *17 precise grades from 9H to 6B*

10D. EACH. 9/2D. PER DOZEN

TRY TURQUOISE DRAWING LEADS AVAILABLE FROM 2B TO 6H

EAGLE PENCIL CO · ASHLEY ROAD · TOTTENHAM N.17 T.38

ONCE AGAIN!



A. Coil Bobbin. Nylon A100M
B. Bearing Arm. Nylon A100M
C. Terminal Plate. Bakelite X20/5 HD
D. Voltage Selector Knob. Nylon A100M
E. Starter Wheel. 'Welvic' P.V.C. Medium Hard
F. Retaining Plate. Nylon A100M
G. Voltage Identification Plate. Melamine M4910
The body is moulded from Melamine M4910 and the Head Guard (not shown) from Styrene Acrynitrile

In 1959 we published a series of three advertisements giving details of our services in connection with the Sunbeam Shavemaster. The fact that we can now give details of the Sunbeam Rollmaster Electric Shaver speaks for itself. It is interesting to note that shavers assembled from mouldings produced—and tooled—by us, are now being sold on the other side of the Atlantic.

The new Sunbeam Rollmaster Electric Shaver is a superlative shaving instrument and incorporates mouldings in a wide variety of plastics. In fact the twenty-two mouldings involved required five different materials, each selected to do a specific job. When quantity production to precise limits is required, and, particularly, when flawless surface finish is essential, we have the plant, resources and technical 'know-how' to ensure complete satisfaction. May we quote for your next job?

Sunbeam choose E. Elliott Ltd

THE PLASTIC MOULDERS
WITH THE ENGINEERING BACKGROUND

315 SUMMER LANE · BIRMINGHAM 19 · Telephone : ASTon Cross 1156 (4 lines)

NEWS ROUND-UP

Electric Co. Ltd. of England are jointly interested, the computer will take into account all the characteristics of the raw material and the furnace, as well as the specifications of the end-products.

Essentially, the computer will determine the amount of raw materials required and will prescribe the amounts and types of additives necessary to produce a given quantity of finished ingots of the correct specifications. It then takes care of the furnace process, controlling the heat generated by adjustment of the flow rate and duration of oxygen blow. In addition to maintaining a consistent product of top quality, this precise control ensures a minimum consumption of raw materials and oxygen. From the data which the computer automatically records, a close relationship between furnace conditions and the characteristics of the finished ingots can be drawn up for use in determining the optimum conditions for subsequent batches. At the same time, the computer programme can be automatically revised as more is learned about the operation of the furnace.

Symposium on the Future of Ironmaking

"The Future of Ironmaking in the Blast-Furnace" is the title of the symposium forming the major technical subject of the general meeting of The Iron and Steel Institute. Ironmaking experts from Belgium, France, the U.K., and the U.S.A. have contributed papers for the four sessions involved, covering injection processes, hot-blast stoves, burden preparation, and furnace engineering respectively. A special session, to follow the symposium on ironmaking, has been organized by The Iron and Steel Engineers Group in connection with the effect of the various steelmaking processes on the energy balance of integrated iron and steelworks. In addition, there will be a series of parallel scientific sessions devoted to the thermodynamics of slags, oxidation and scale, bainite, and the effects of steelmaking practice on the mechanical properties of alloy steels.

The symposium on ironmaking and the session on the energy balance of integrated iron and steelworks will be held at the Federation of British Industries, Tothill Street, London, S.W.1, on November 29 and 30, and on December 1, 1961, respectively. The scientific sessions will take place at the offices of The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1, on November 29 and 30. Full details of the programme of papers will be circulated shortly.

Rockwell Machine-Tool Exhibition

As announced by the Rockwell Machine Tool Co. Ltd., an exhibition of machine tools will be held at their London showrooms at Welsh Harp, Edgware Road, N.W.2, between November 7 and 22, 1961, inclusive. The exhibition, which will be open from 10 a.m. to 5 p.m., Mondays to Fridays, will feature some 60 high-production and toolroom machines of British and Continental manufacture, all of which will be displayed and demonstrated under power.

British machines will include "Matrix" thread grinders, worm grinders, jig borers, and jig grinders, and Matrix/Thompson surface grinders, all these machines being manufactured by the Rockwell associates, the Coventry Gauge & Tool Co. Ltd. Among Continental machines, Fritz Werner multi-channel programme-controlled and tape-controlled milling machines, direct from the recent Brussels Exhibition, will be shown for the first time in the U.K. Other exhibits will include the new British Clearing "Torc-Pac" O.B.I. presses, the latest Thiel toolroom machines, the Giddings & Lewis-Fraser "Hybormill" horizontal boring, drilling, and milling machine, Diskus segmental-wheel surface grinders, Jung fully automatic internal grinders, British-built "U.S." multi-slide machines, Peltzer & Ehlers cold-forming machines, and the latest Schutte six-spindle automatic and tool and cutter grinders.

Conference on International Developments in Heat Transfer

The major conference after World War II with which The Institution of Mechanical Engineers was concerned was a general discussion on heat transfer, arranged jointly by The American Society of Mechanical Engineers and The Institution of Mechanical Engineers. This discussion was held in London in 1951 and was later repeated in the U.S.A. in Atlantic City in the same year. About 100 papers were discussed, the object being to review developments in the knowledge of the principles of the transference of heat and in the design of equipment in which use had been made of such knowledge as had come to light between 1940 and 1950.

Following the success of this conference, it was decided that a second conference on the fundamentally important subject of heat transfer should be held on both sides of the Atlantic. This second conference was first held in Boulder, Colorado, from August 28 to September 1, 1961, and will be repeated in London from January 8 to 12, 1962, at the Lecture Hall, Central Hall, Westminster. At the London conference, which has been arranged by The Institution of Mechanical Engineers, The American Society of Mechanical Engineers, and The Institution of Chemical Engineers, papers will deal with the fundamental aspects of heat transfer, but will include papers devoted to technology and other papers covering such fields as nuclear energy and aeronautical sciences. The aspects to be dealt with include radiation, convective heat and mass transfer, condensation and boiling, and conduction and diffusion.

Four special lectures were included at the Boulder conference, respectively entitled "Some Reflections on Progress in Engineering Heat-Transfer Science", "Research during the Last Decade on Forced-Convection Heat Transfer", "Heat Transfer by Natural Convection", and "Problems of Radiactive Transport". It is hoped to arrange for the re-presentation of these lectures at the London conference. A preliminary programme of the London conference and registration forms can be obtained on application to The Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

Classified Advertisements

"BILLETER" TWIN-HEAD RADIAL ARM OPEN SIDED HYDRAULIC SLIDEWAY GRINDER for sale. Table 9 ft. 8 in. by 2 ft. 3 in. F. J. Edwards Limited, 359, Euston Road, London, N.W.1. or 41, Water Street, Birmingham 3.

Molyslip is a product of **THE SLIP GROUP OF COMPANIES,** 34 Great St. Helens, London, E.C.3 Tel: AVEnue 1636. Telex: 23755

Technical literature on request from: MONKS & CRANE LIMITED, HEAD OFFICE: GARRETTS GREEN LANE, BIRMINGHAM, 33, STECHFORD 4051 *and branches at:* LONDON: 204/206 WEST END LANE, LONDON, N.W.6. HAMPSTEAD 9624 • MANCHESTER: 8 WILMSLOW RD., MANCHESTER 14. RUSHOLME 6224 • GLASGOW: 6/8 POSSIL RD., GLASGOW, C.4. DOUGLAS 6011 • NEWCASTLE-ON-TYNE: 23 DEAN ST., NEWCASTLE-ON-TYNE 1. NEWCASTLE 29773 • LEEDS: 52 WELLINGTON ST., LEEDS 1. LEEDS 33086 • BRISTOL: 9 STOKES CROFT, BRISTOL 1. BRISTOL 294331 • BELFAST: 26 ANTRIM RD., BELFAST 14. BELFAST 746111

NEW TECHNICAL BOOKS

High-Voltage Distribution Practice. Edited by J. H. Gridley, B.Sc.(Eng.), Ph.D., A.M.I.E.E. 240 pp., 82 illustrations. Publishers: Ernest Benn Ltd., Bouverie House, Fleet Street, London, E.C.4. Price: 45/–.

To give engineers concerned with the distribution of electricity an opportunity of learning how senior engineers from various parts of Great Britain have approached their problems, a symposium of lectures was held some time ago at the Regent Street Polytechnic, London. The substance of these lectures forms the greater part of this interesting and well-produced book, and covers seven aspects of the subject, each by a recognized expert in his field.

The book discusses system planning on the basis of providing a cheap and abundant supply to consumers within the statutory limits of declared pressure, and examines the practical aspects of overhead-line equipment, including problems related to corrosion, contamination, vibration, and erection. Details of substation design are given with special reference to the important considerations that must be borne in mind if the station is to operate reliably for long periods with a minimum of attention. In addition, relay schemes are described and compared, and, in view of the frequency of faults in overhead systems caused by lightning, a discussion is included on lightning protection. Finally, the importance of operation and maintenance engineers' records in assessing the reliability of plant and in estimating trends is illustrated.

Metallic Fatigue. By W. J. Harris, M.Sc., F.Inst.P. 342 pp., 123 illustrations. Publishers: Pergamon Press Ltd., Headington Hill Hall, Oxford. Price: 84/–.

Providing a broad survey of the major factors affecting the fatigue behaviour of metals, with particular reference to the significance of certain standard aircraft fabrication and finishing processes, this book has all the stamp of authority to be expected from the author, who is chief physicist to the de Havilland Aircraft Co. Ltd.

Theoretical considerations include such matters as stress concentration, frequency effects, corrosion, fretting, crack propagation, and statistics, while the research described to indicate possible solutions to fatigue problems has mainly been selected on the grounds of feasibility with conventional well-equipped engineering facilities. There can be no doubt that the method of treatment of the subject, coupled with details and illustrations of a wide range of testing facilities and an up-to-date and comprehensive bibliography, make this book an invaluable reference work.

Cybernetics. 2nd Edition, 1961. By Norbert Wiener. 230 pp., 11 illustrations. Publishers: The M.I.T. Press, Cambridge, Mass., and John Wiley & Sons Ltd., Gordon House, Greencoat Place, London, S.W.1. Price: 52/–.

Dealing with the close study of human control functions and of the mechanical and/or electrical systems designed to replace them, cybernetics itself is a new science, actually named by Dr. Wiener and his colleagues in 1947. Because of its nature, it touches on every branch of science in which control or communication plays a part, and stems from the results of a wide theoretical study and experimentation by the author, who is Professor of Mathematics at the Massachusetts Institute of Technology, and a number of outstanding scientists.

The book represents the first complete statement of the science of control and communication in animals and machines, with its many ramifications and ever-increasing implications for science and human existence in general. In a very strict sense, it describes the application of methods of statistical mechanics to communications engineering, with subject matter ranging from such control mechanisms as mathematical calculators to the nerves and brain of the human body. This new and revised second edition has been completely re-edited and includes a new introduction by the author and two new completely new chapters, i.e., on learning and self-reproducing machines, and on brain-waves and self-organizing systems. It should also be added that, although the subject is an interesting one, Dr. Wiener contrives to make it even more interesting by his lucid and concise style of writing.

Stress Concentration around Holes. By G. N. Savin. 440 pp., 208 illustrations. Publishers: Pergamon Press Ltd., Headington Hill Hall, Oxford. Price: 84/–.

When designing engineering structures and machines in accordance with modern principles, it is essential to combine adequate strength and rigidity with a minimum quantity of constructional materials. For this purpose, various factors must be taken into account, one of these being the question of stress concentration around holes and recesses in plane and three-dimensional parts. Of considerable interest to engineers and mathematicians, this book, which has been translated from the original Russian of Dr. Savin by Eugene Gros for the Department of Scientific and Industrial Research, deals thoroughly with the problem of stresses set up around holes of various shapes in beams and plates subject to different kinds of loading.

This outstanding book mainly consists of the results of work carried out by the author and his students over the past fifteen years, though the results obtained by other authors in this field are also included. The most important results on stress concentration are clearly compiled in the form of graphs and tables, making it possible for engineers and designers to arrive at important conclusions without having to make a detailed study of the theory involved.

Electronics: A Bibliographical Guide. By C. K. Moore, B.Sc., and K. J. Spencer, A.L.A. 428 pp. Publishers: Macdonald & Co. (Publishers) Ltd., 16 Maddox Street, London, W.1. Price: 65/–.

As an indication of the extraordinarily extensive literature dealing with electronics, it may be mentioned, as a few examples, that some 1500 papers are published yearly on dielectrics, about 1000 papers on semiconducting materials, 1500 papers on transistor characteristics and applications, 3500 papers on electronic computers, and 100 papers on such a specialized field as electrical contacts. It is therefore evident that some guide to this wealth of literature is, to say the least, desirable, and there can be no doubt that this book caters for this need admirably.

Covering the period 1945 to 1959, the book lists directly the major works in electronics literature, i.e., authoritative textbooks, survey articles, main conventions and conferences, and the numerous papers in which have been presented significant advances in the science of electronics, together with a large number of valuable tutorial papers. In addition, means are provided to locate any particular paper in the vast field of electronics. For this purpose, after a comprehensive section dealing with information and reference media of all types, the appropriate specialized bibliographies are listed in each of the remaining 67 sections of the book. In this connection, it should be noted that, as far as the authors are aware, this is the first time that an attempt has been made to compile a bibliography of bibliographies on electronics. A comprehensive index of authors and of subjects is also included.

What a clever way to make tubes

One minute you have strip in the coil—click goes a very clever machine and presto you have Helitube. Helitube can be made from 3½" to 24" dia. It is very strong, pressure tested to 15lb. per square inch internally—yet it is extremely light and costs less than conventional tube.

METAL SECTIONS LTD

A GKN COMPANY

OLDBURY · BIRMINGHAM *Tel: BROadwell 1541*

Helitube has so many uses; fill in the coupon for full details. E.D.

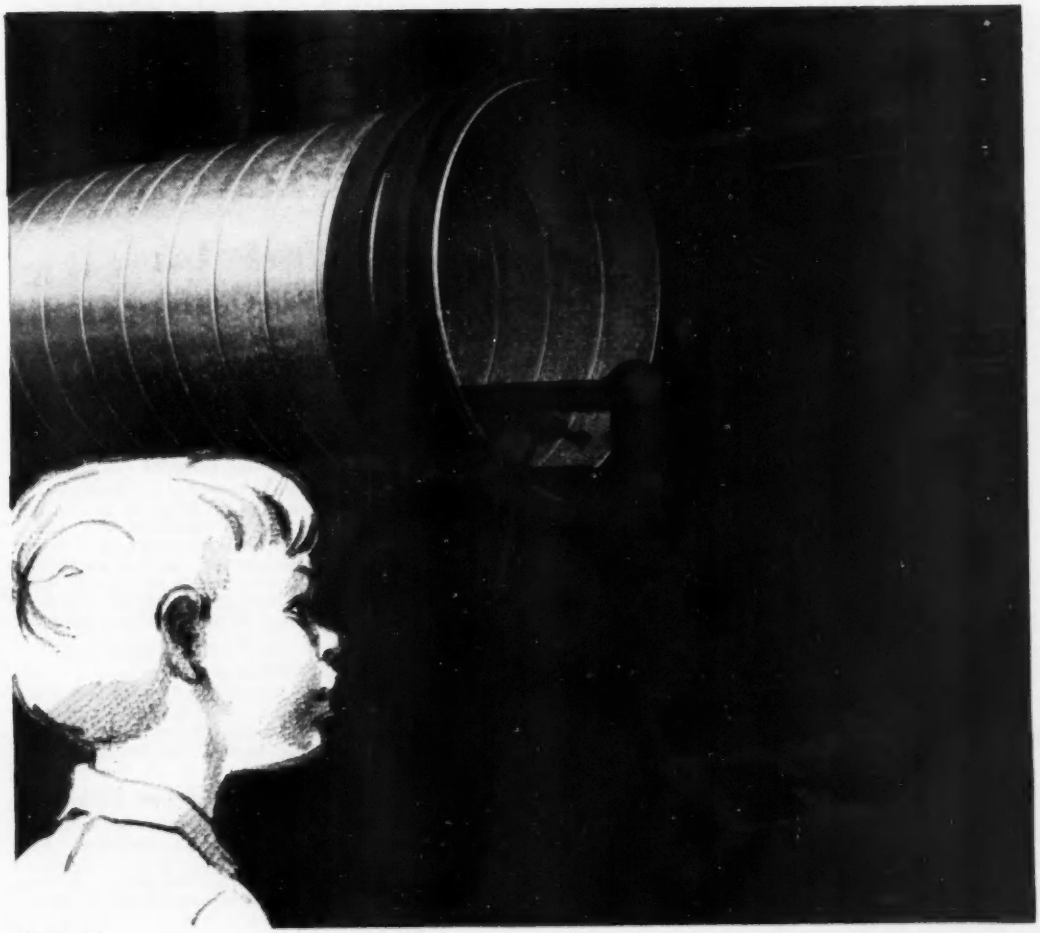
Name .....

Position .....

Company Address .....

.....

.....



SM/MS 5853

LATEST INDUSTRIAL LITERATURE

Materials

1. Heat-Resisting Alloys

A 76-page catalogue serves as a useful guide to the properties, selection, and application of a range of heat-resisting alloys. Information on the heat-treatment, welding, and fabrication of the alloys, as well as on the thermal fatigue, attack by fuel ash and molten metals, and limiting service conditions is given.

2. Steels and Tool Materials

The range of steels dealt with in a 16-page brochure includes high-speed, hot-work, press-tool, stainless, and acid- and corrosion-resisting steels. Details of nickel-chromium electrical resistance alloys, high-speed steel and tungsten-carbide cutting tools, and tool materials are also incorporated.

3. Precious Metals

Particulars are contained in a 28-page brochure of a wide range of precious metals, including gold, silver, platinum and palladium contact materials, platinum-group and gold electrodeposits, silver brazing alloys, and silver-bearing soft solders, as well as machinable high-density alloys containing tungsten, nickel, and copper.

4. Engineering Resins

Available in granules for injection moulding or extrusion, in fine powder for metal coating, and in film, tube, or continuous monofilament form, a range of engineering resins is dealt with in a 12-page brochure. Descriptions of the physical and electrical properties of the resins are given and a chapter on the sawing, drilling, turning, milling, tapping, polishing, and grinding of these resins is also included.

5. Laminated Resins

Developed for use in drilling jigs, forming tools, checking fixtures, foundry patterns, core boxes, chemical-plant lining, aircraft components, propellers, gear wheels, etc., a range of laminated resins is described in a 24-page brochure. Information is given on the choice of resins and curing agents and on the application of fillers and reinforcements.

6. Uses for P.t.f.e.

A 4-page brochure deals with a range of p.t.f.e. products, selected applications of which include stress-free sheets, blocks, cylinders, rods, reinforced components, small machined parts, moulded or coined forms, and dispersion coatings.

MAIL THIS COUPON TO-DAY

THE ENGINEERS' DIGEST, 10.61
120 Wigmore Street, London, W.1.

Date.....

Please send free and without obligation the literature indicated by the following circled numbers:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

33 34 35 36 37 38 39 40 41 42 43

Name .....

Position .....

Company.....

Address .....

.....

7. Thermosetting Resins

Properties, specifications, and methods of processing are given in a 28-page catalogue of a range of synthetic thermosetting resins. Chapters are included on adhesives, laminates, and resins for foundries, as well as data sheets on the various grades of resins available.

Components

8. Needle Bearings

The range of needle bearings fully described in a 138-page catalogue includes light and heavy, single- and double-row needle bearings, adjustable, shell type, and self-aligning needle bearings, and combined needle thrust bearings. Details of needle rollers, seals and circlips for needle bearings, and cam and roller followers are also incorporated.

9. Split Roller Bearings

A 36-page catalogue describes a range of split roller bearings which can be applied with advantage in conditions where it would be impracticable to mount solid ball or roller bearings. Each bearing comprises split inner and outer races, two split clamping rings, and a split cage containing the rollers. Styles for pedestals, mounting arrangements, load-carrying tables, and a selection of typical applications are included.

10. Clutches

Suitable for high-speed over-running without backlash on the output shaft and providing a high torque/size ratio, a range of reversible-locking clutches is described in an 8-page brochure. The clutches are entirely mechanical in operation and can be used for the position control of lifts and elevators, data-processing equipment, machine tools, for reversible backstop of gear boxes and conveyors, and for single-revolution control in printing and office machinery.

11. Industrial Disc Brakes

Ideally suited for applications where there are space limitations or where repeated operation is required without brake fade, a range of industrial disc brakes is presented in a 12-page brochure. Description is also given of the various calliper units incorporated in the brakes and reference is made to automatic clutch couplings transmitting up to several thousands of b.h.p.

Finishing Materials and Equipment

12. Colour Conscription for Industry

Incorporating practical suggestions in order to improve the effects of natural and artificial lighting, to eliminate eye fatigue, and to emphasize the safety requirements in workshops and factories, a 20-page brochure contains particulars of colour conscription for industry. Information is given on critical and non-critical colours, on colour and safety, on standard colour code, and on the painting of machines and walls in machine shops, etc.

13. Vitreous Enamelling

A 4-page brochure contains details of a range of vitreous enamelling service, materials, and equipment, such as fusing furnaces, drying ovens, pickling plant, spray booths, colouring oxides, flocculating agents, mill-room equipment, etc.

14. Compressors and Spray-Painting Equipment

The range of compressors and spray-painting equipment described in a selection of data sheets includes stationary compressors of from 5 to 65 cfm capacity, spray booths, spray guns, pressure regulators, filters, various accessories, as well as completely automatic spraying machines.

Castings and Pressings

15. Steel Castings

Details of design and production of a range of steel castings are given in an illustrated 12-page brochure. Small castings are made in oil sand mixtures which give good surface finish, while large castings are moulded in dry sand, and prior to stoving all moulds are coated with a zircon-base paint which aids stripping and improves surface quality. All steels are melted in basic direct arc electric furnaces, and considerable facilities are provided for the analysis and inspection of castings.

16. Iron Castings

Diesel-engine bedplates, lathe beds, radial driller arms, and gear housings are some of the examples of the range of iron castings produced by a leading manufacturer. Three large moulding pits are available for castings up to 18 tons in weight, while small castings are produced by the green, dry, and CO_2 sand processes.

17. Bronze Castings

Produced by various casting techniques, such as centrifugal casting, shell moulding, etc., a range of cast bronzes is described in a 60-page catalogue. Properties of the various bronzes are given and a large number of components manufactured by the above methods is described and illustrated.

18. Precision Investment Castings

Covering a wide range of materials from gun metals to mild steel and nickel-chromium alloys, details of precision-investment castings are given in a 4-page folder. It is usually possible to produce components with an accuracy of $\pm 0{\cdot}004$ in. on dimensions up to 1 in, the machining of which can be limited to grinding, reaming, or tapping.

19. Non-Ferrous Pressings

A 12-page brochure lists the properties, specifications, and applications of a range of non-ferrous hot pressings. Components are supplied for the general engineering, aircraft, electrical, and other industries, the chief advantage of the pressings being light weight, good surface finish, and saving in machining operations.

Pneumatic and Hydraulic Equipment

20. Pneumatic Controls

A 4-page folder contains details of pneumatic control valves, air cylinders, air-flow regulators, manifolds, filters, etc. Information on the use of air equipment in machine tools and engineering equipment is also given.

21. Air Control Valves

The range of air control valves described in a series of leaflets and data sheets includes three- and five-port piston, poppet, and mushroom valves, air-flow regulators, pressure-sensitive relay valves, etc. Details of process timers, lubricators, and drain valves are also included.

22. Square-End Air Cylinders

A new range of double-acting square-end air cylinders is introduced in a 4-page brochure. Each cylinder is available with neck, leg, front, or rear-plate mounting. An additional leaflet presents particulars of air-control valves, lubricators, blow guns, quick-acting couplers, etc.

23. Pneumatic Valves for Automation

A wide range of pneumatic valves for automation of machine tools and industrial processes is dealt with in a 20-page brochure, including 4-way pilot-operated spring-return valves, cam- and hand-lever operated valves, and valves for panel mounting. The spools and sleeves of the valves are equally suitable for air or vacuum.

24. Hydraulic Equipment

An illustrated 42-page catalogue contains particulars of a wide range of hydraulic equipment, such as rotary actuators with and without volume compensation, manual, power-driven, and electric pumps, various valve units, and a range of accessories and pipe fittings. Data sheets on torque characteristics of hydraulic presses, operating times for actuators, and linkages for open and close circuits are also incorporated.

25. Hydraulic Cylinders

Suitable for pressures up to 2000 psi, and available with ten various arrangements, such as clevis, rod-end, flange, trunnion, foot, and centre-line mountings, a range of hydraulic cylinders is presented in a 24-page brochure. Details of rod styles, cushioning, and accessories, as well as nomograms of pipe capacities, safe-rod lengths, and power requirements are given.

26. Screw Pumps and Hydraulic Motors

A new range of screw pumps and hydraulic motors introduced in an illustrated 10-page brochure includes foot-, flange-, or cartridge-mounted low-, medium-, and high-pressure pumps up to 2500 psi. The range of accessories particularly suited for machine tools includes flow controllers, feed units, regulating pumps, and profile tracers. Details are also given of power-pack units for hydraulic presses, diecasting machines, etc.

Electrical Equipment

27. Silicon and Germanium Rectifiers

An illustrated 20-page brochure contains particulars of a range of silicon and germanium rectifiers recommended for applications in electrolytic processing plant, power generation, traction, etc. Guidance is given to the selection of rectifiers, and details of cooling arrangements, connections, etc., are also included.

28. D.C. and Induction Motors

Particulars are presented in a 12-page brochure of a range of marine and industrial d.c. motors from $1\frac{1}{4}$ to 250 h.p., with horizontal and vertical mounting. An additional 4-page brochure contains details of vertical squirrel-cage and slip-ring induction motors available in sizes of from 5 to 600 hp and supply pressures of up to 6000 V.

29. Fan-Cooled Cage-Rotor Motors

A new range of totally-enclosed fan-cooled cage-rotor motors is described in a 6-page folder. The motors satisfy the recommendations of the relevant standards but offer increased outputs or reduced temperature rise, and therefore can be used with advantage where reduced rotor inertia or weight is desirable.

(*Concluded on page 31*)

MAIL THIS COUPON TO-DAY

THE ENGINEERS' DIGEST, 10.61
120 Wigmore Street, London, W.1.

Date .....

Please send free and without obligation the literature indicated by the following circled numbers:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
33 34 35 36 37 38 39 40 41 42 43

Name .....

Position .....

Company .....

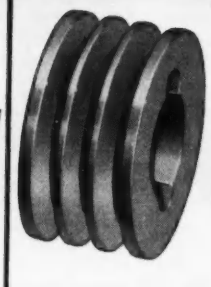
Address .....

.....

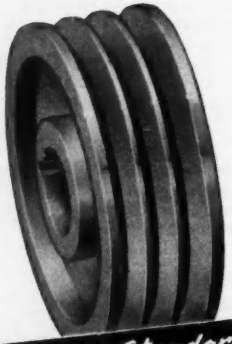
There are no better pulleys than *Collingwood*

Stock Pulleys
Standard Pulleys
SPECIALS
ONE OFF OR QUANTITIES

V-BELT
COM-PAC Wedge V
LINK-V
AND SPECIAL GROOVING

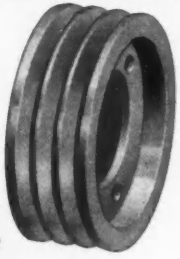


Stocks of Atlas TAPER BUSHED V PULLEYS



Stock & Standard Cast Iron V-PULLEYS

Domed Plate



Flange Mounted

SPECIALS

Brake Drum

Step Cone

✻ *Top Engineering Quality*
✻ *Competitive Prices and Deliveries*

The London Shafting & Pulley Co. Ltd.
COLLINGWOOD IRON WORKS
13-22 NORTHDOWN STREET · KING'S CROSS · LONDON N.1.
Telephone: Terminus 4721, 4722, 4723, 6578. Telegrams: Chasaloy, Norde, London.

Attach this cut-out to your letter heading

- *Please send NEW comprehensive V-pulley catalogue*

Name .....

.....

Position .....

LATEST INDUSTRIAL LITERATURE

(*Concluded from page 29*)

30. F.h.p. Motors

Giving torques of from 1·75 oz.-in. to 150 lb. in. and final shaft speeds of from 28 to 562 rpm, a range of geared and gearless f.h.p. motors is presented in a 10-page brochure. Details of switching arrangements, mounting positions, and selected applications are described.

31. Relays and Controls

Operational characteristics are given of a range of relays and control equipment in a 52-page brochure, including miniature plug-in and multi-contact relays, contactors, and latching, load-detector, and measuring relays, as well as auto-resetting timers, photo-electric receivers, rotation-sensing devices, control panels, etc.

Industrial Equipment

32. Water-Tube Boilers

Designed for stoker firing, pulverised fuel, and gas or oil firing, a range of water-tube boilers is presented in a 20-page brochure. The boilers are claimed to provide high steam purity and accurate superheat control, complete combustion of the fuel, and highest possible availability at the maximum thermal efficiency.

33. Salt-Bath Furnaces

Providing temperatures of up to 1400°C for hardening, tempering, annealing, cyaniding, descaling, etc., a range of electrode salt-bath furnaces is described in an 8-page brochure. A range of midget salt-bath furnaces for the heat treatment of small components is also included.

34. Heat-Treatment Furnaces

Uniform heating, accurate temperature control, high-velocity air flow, and compact design are some of the salient features of the vertical batch-type heat-treatment furnaces introduced in a 4-page brochure. The furnaces are suitable for tempering, secondary hardening, stress relieving, etc., and, by inserting the charge in a gas-tight chamber, can also be adapted to nitriding.

Machine Tools and Workshop Equipment

35. Honing Machines

Suitable for batch production of components of from 1 to 6 in. internal diameter and from 2 to 36 in. in length, a range of multi-purpose honing machines is presented in a 4-page folder. The provision for short stroking in any section of the bore is invaluable in rapidly removing closures and inaccuracies caused by previous machining. A full range of hydraulic tooling is available, and clamping fixtures are supplied in transverse, rotary indexing, or single-station versions.

36. Oxygen Cutting and Profiling Machines

Equipped with a special tracer which has an optical steering device and makes it possible to cut intricate shapes to high accuracy, a range of oxygen cutting and profiling machines is described in a 6-page brochure. The machines have specially constructed dual carriages and automatic controls for burner lighting and burner-height adjustment. For plate edge preparation a special flame-planing head is available, and the machine is also adaptable to automatic profile welding.

37. Multi-Slide Stamping Machines

Eminently suitable for the production of intricate stampings from coiled material in one operation, a multi-slide stamping machine is described in an 8-page brochure. The machine, which is fitted with four forming slides and has an extreme accuracy of feed, saves a great deal of material, as no extra width of coil is required for piloting or side cropping.

38. Cemented Carbides

A 24-page catalogue contains information on the properties and performance of cemented carbides, the applications described of which include riveting hammers, cam followers, gauging rods, bushings, band-saw guides, wear rings for scarfing torches, swaging dies, shot-blast blades, chuck jaws, knurling wheels, pulverizing hammers, compacting dies, etc.

39. Turning Tools

The range of turning tools described in a series of leaflets includes round-nose, boring, bar-turning, cranked-knife, square-shank, and straight-recessing tools. Additional leaflets contain details of die-sinking cutters, slot mills, reamers, etc.

40. Precision Holding Tools

Providing quick change-over, reduced tooling time, and increased production rates, a range of precision tool holders is introduced in a selection of brochures, including floating holders with collets and shanks, tap drivers, automatic recessing tools, etc.

41. Carbide-Tipped Tools

Information is presented in a 12-page brochure on the performance and multifarious applications of a range of carbide-tipped cutting tools, such as reamers, cutters, tipped saws, and combination tools. A useful table for the selection of tungsten-carbide grades for various applications is also included.

42. Liquid Sealants

Eliminating the necessity for self-locking nuts or washers, interference fits, socket screws, etc., a range of liquid sealants is described in a 16-page brochure. The sealants are claimed to improve the reliability of threaded inserts, providing high resistance to vibration. In addition, they do not require any preparation and the screws treated can be removed by ordinary tools.

43. Cutting Fluids

Properties and applications are listed in a 64-page catalogue of 43 grades of cutting fluids and useful recommendations are given on the use of these fluids in various machining operations, such as turning, milling, broaching, threading, etc. A chart on the effect of different metals on fluid performance is also included.

MAIL THIS COUPON TO-DAY

THE ENGINEERS' DIGEST, 10.61
120 Wigmore Street, London, W.1.

Date .....

Please send free and without obligation the literature indicated by the following circled numbers:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

33 34 35 36 37 38 39 40 41 42 43

Name .....

Position .....

Company .....

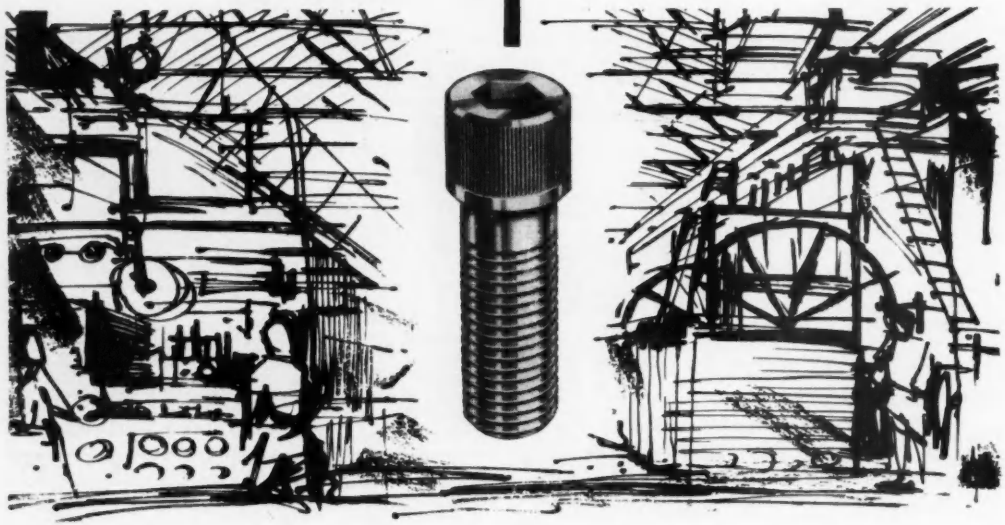
Address .....

.....

Unbrako high-performance socket head cap screws are made in a vast range of sizes and threads to cover every need.
A descriptive brochure is yours for the asking.

Performance is measured by true dimensions

Research, craftsmanship and rigorous control combine to make Unbrako screws the world's safest, each produced with that unerring dimensional accuracy which ensures unfailing performance. Dimensional accuracy includes the dimension which can only be measured in retrospect. The dimension of in-built performance. Millions of Unbrako screws have been proving this for years.

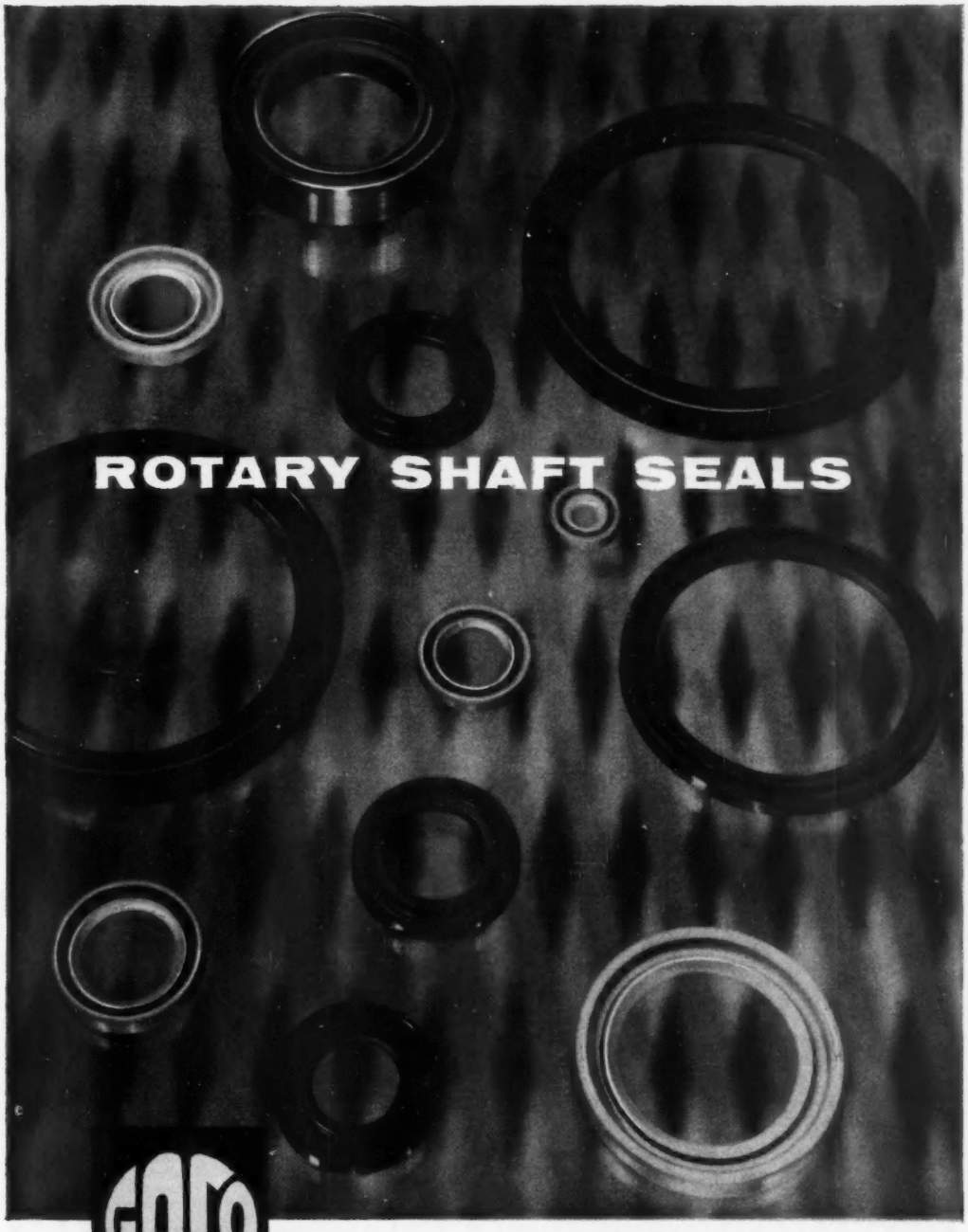


UNBRAKO

UNBRAKO SOCKET SCREW CO LTD COVENTRY TEL: 89471

ALSO MAKERS OF: CAP SCREWS · BUTTON HEAD SOCKET SCREWS · COUNTERSUNK SCREWS · WEDGLOK SCREWS · PRESSURE PLUGS · RING BOLTS · SET SCREWS · SHOULDER SCREWS · SQUARE HEAD SET SCREWS · T BOLTS · T NUTS · SEL-LOK · STAINLESS STEEL AND COLLARS

UNBRAKO SCHRAUBEN Gm. b. H. KOBLENZ · UNBRAKO STEEL CO. LTD., SHEFFIELD, ENGLAND



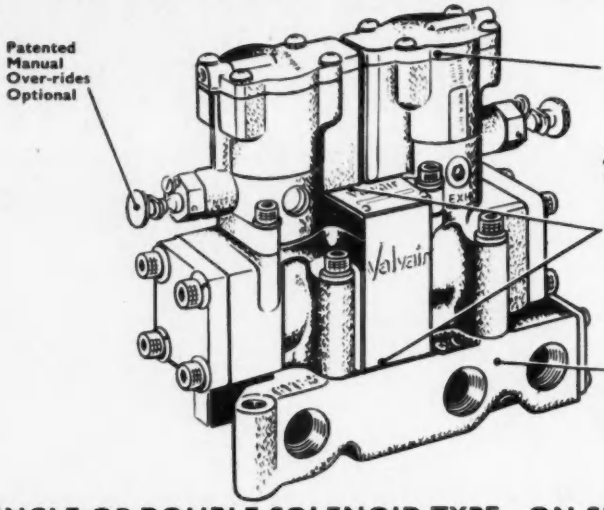
IN GACO AND SILICONE RUBBERS

GEORGE ANGUS & Co LTD
OIL SEAL DIVISION, COAST ROAD, WALLSEND-ON-TYNE
Telephone: Wallsend 624551 · Telex: 53138 · Telegrams: Gaco Wallsend

From the **Bellows-Valvair** Range

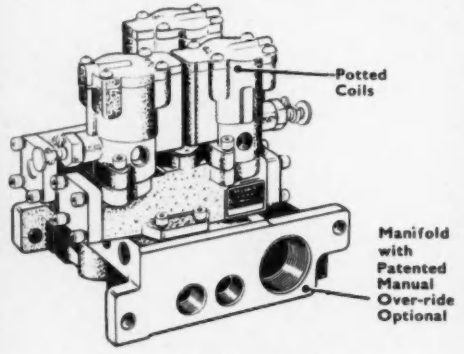
SPEED KING **PLUG-IN** SOLENOID AIR VALVES

✱ **PLUG-IN** eliminates disturbance of electrical and pneumatic connections during routine maintenance

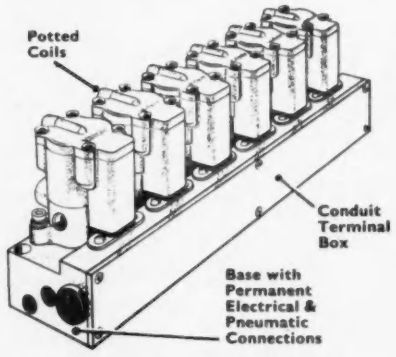


SINGLE OR DOUBLE SOLENOID TYPE - ON SUB BASE

MULTI-MILLION CYCLE LIFE . . . . COILS GUARANTEED AGAINST BURN-OUT FOR VALVE LIFE



PLUG-IN SPEED KING MANIFOLDS 2 & 3 STATIONS

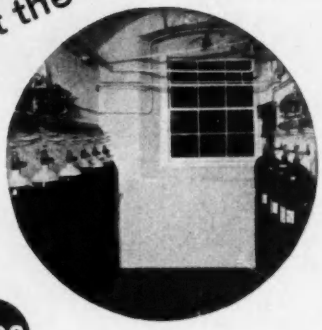


PLUG-IN PILOT VALVE MANIFOLDS UP TO 6 STATIONS

BELLOWS-VALVAIR LIMITED, 1206 STRATFORD ROAD, HALL GREEN, BIRMINGHAM 28 - Tel: SPRingfield 6059

controlled
variable
speed
Kopp VARIATORS
ALLSPEEDS LIMITED
Royal Works · Clayton-le-Moors, P.O. Box 43, Accrington, Lancashire · Telephone Accrington 35441 (6 lines)
Technical Representatives in LONDON · BIRMINGHAM · MANCHESTER · LEEDS · BRISTOL · GLASGOW

First the billet...



CTCO

1. Oxygen and nitrous oxide manifolds in hospital surgical section. (*With acknowledgements to British Oxygen Gases Ltd.*)

2. Local application fire extinguishing system installed in printing works. (*With acknowledgements to the Walter Kidde Co. Ltd. and Sun Printers Ltd., Watford.*)

then the cylinder

Many are the end uses for Chesterfield seamless steel gas cylinders; more than 10,000,000 manufactured to date, pierced and drawn from solid billets of steel. Cold drawn seamless steel Chesterfield cylinders are produced to conform to the specifications and regulations ruling in all countries, and are as perfect as our modern plant and manufacturing "know-how" can make them.

chesterfield tubes

THE CHESTERFIELD TUBE COMPANY LIMITED
CHESTERFIELD, ENGLAND
A MEMBER OF THE GROUP

CTC 80

Replacing a headed pin

ROLLPIN

In hinge pin application, Rollpin is simply and inexpensively pressed into place, greatly reducing assembly costs. Constant spring tension holds the Rollpin firmly in position ... minimises hinge wear.

Replacing a bolt and nut

ROLLPIN

Rollpins act as fasteners and pivots for the linkages in this Electric Welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements. Self-locking action prevents side motion of pin, reducing wear.

Replacing a hub on a gear

ROLLPIN

The Rollpin, self-retaining in the shaft, is simply snapped into the moulded slot to position sintered gear. This application effects major assembly savings. The high shear strength of the Rollpin is particularly valuable here.

Replacing set screws on a thrust bearing

ROLLPIN

Originally set screws were used on this outside retaining ring. This meant a costly drilling and tapping operation. The retainer ring is now positioned by six Rollpins. The change-over to Rollpin cut assembly costs by over 50%.

The Rollpin has proved its value as a simple, reliable and uncomplicated single piece fastener which may be inserted or removed by hand or power tools.

THE TEMPERED SPRING COMPANY LIMITED

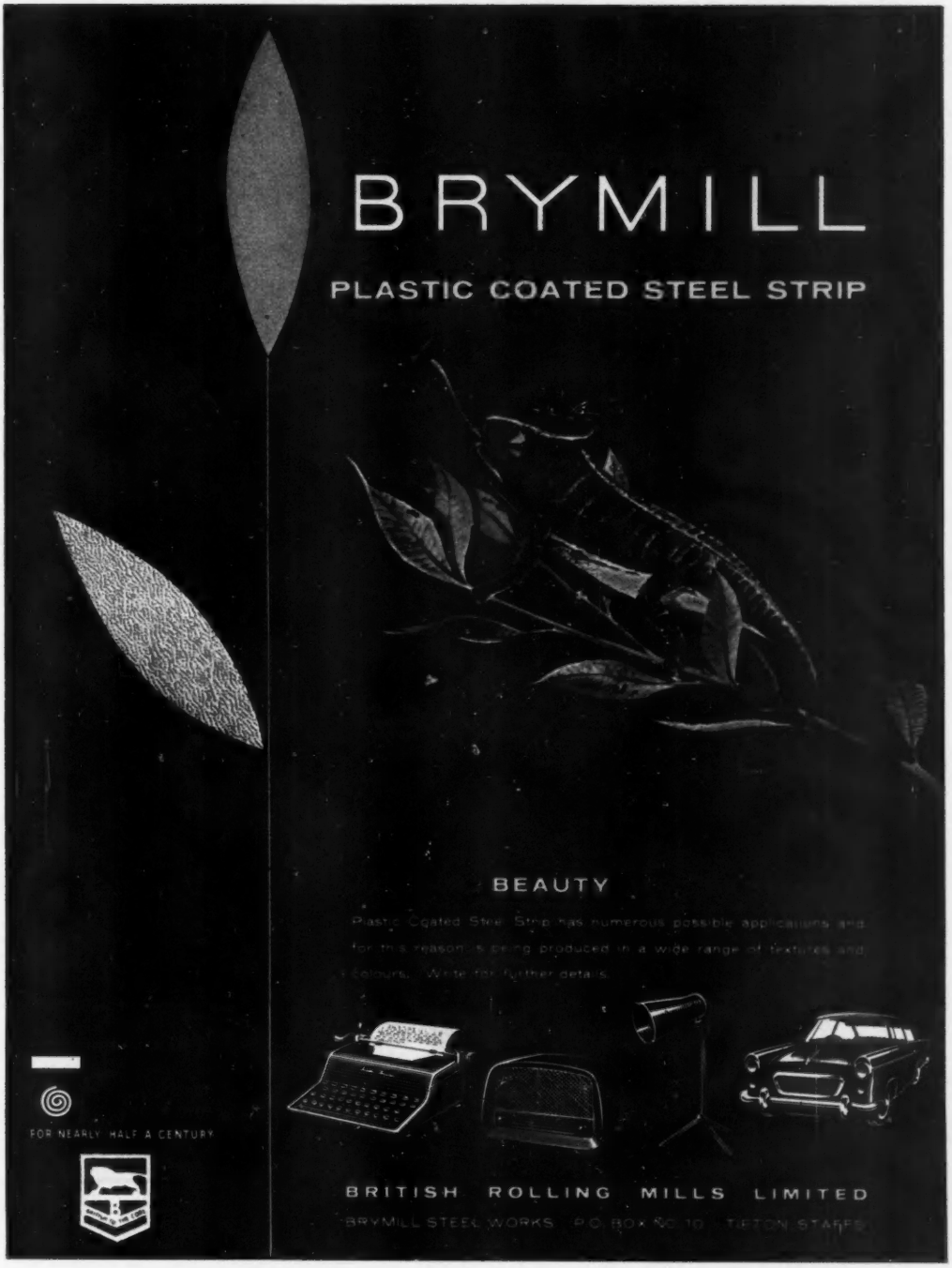
SHEFFIELD

TELEPHONE 23354-5
TELEGRAMS
TEMPERED SHEFFIELD TELEX 54-103

P.O. BOX 17
WARREN STREET
SHEFFIELD, 4

A Member of the Tempered Group

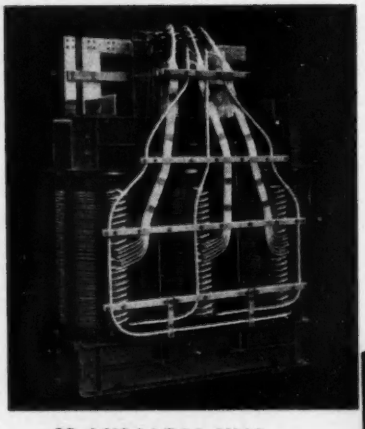
Also distributed and stocked by Davis & Timmins Ltd., at London, Birmingham, Manchester, Bristol, Newcastle, Bridgend, Leeds, Glasgow and Edinburgh.


BRYMILL
PLASTIC COATED STEEL STRIP
BEAUTY
Plastic Coated Steel Strip has numerous possible applications and for this reason is being produced in a wide range of textures and colours. Write for further details.
FOR NEARLY HALF A CENTURY
BRITISH ROLLING MILLS LIMITED
BRYMILL STEEL WORKS P.O. BOX 6C 10 TIPTON STAFFS

Large — medium — small

TRANSFORMERS

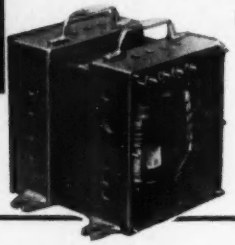
by Hackbridge



23 MILLION KVA IN SERVICE

ABOVE: One of three 100 MVA 220 kV type ON transformers for Tasmania.

CENTRE: 1500 kVA distribution transformer for the Far East.



BELOW: Low power multipurpose unit.

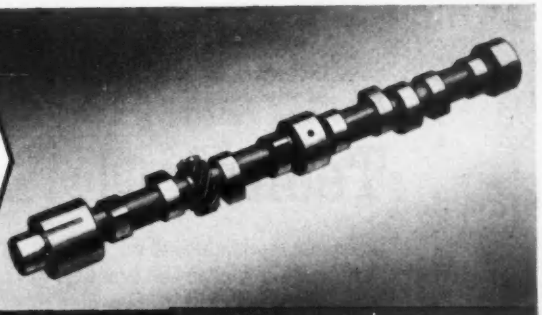
Send for publications.

HACKBRIDGE AND HEWITTIC ELECTRIC CO. LTD

HERSHAM · WALTON-ON-THAMES · SURREY

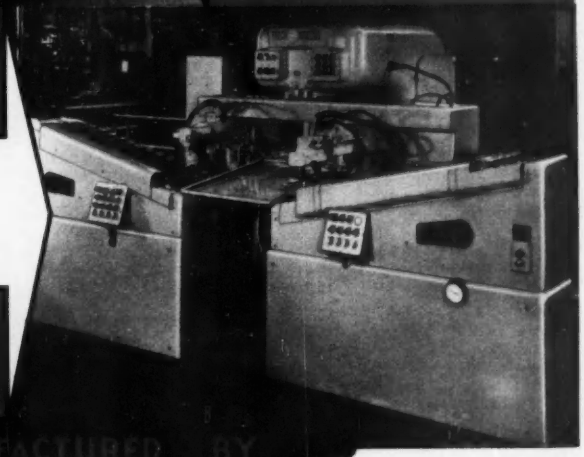
Telephone: Walton-on-Thames 28833 (9 lines) *Telegrams & Cables: "Electric, Walton-on-Thames"*

The combined distributor and oil pump drive gear on the camshaft...



...of this Brilliant NEW Vauxhall Victor was shaved...

...on a G.C.U. 12" model Universal Gear Shaving Machine fitted with automatic loading & unloading equipment



MANUFACTURED BY

SPUR AND HELICAL GEAR SPECIALISTS
ORIGINATORS OF ROTARY SHAVING, GEAR HONING AND ELLIPTOID

PRECISION GEAR MACHINES & TOOLS LIMITED

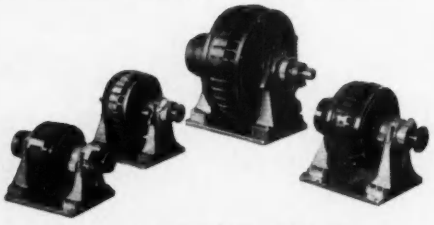
(An Associate Company of National Broach & Machine Co., Detroit, U.S.A.)
"World's Largest Producer of Gear Shaving Equipment"

RED RING WORKS, BODMIN ROAD, COVENTRY

Telephone: Walsgrave-on-Sowe 2372 *Telegrams:* Pregearmac, Coventry

Technical "know-how"

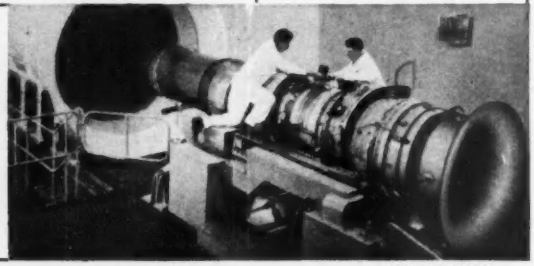
Since our establishment in 1881, we have amassed a fund of detailed technical knowledge and practical working experience which has placed us in a unique position. Nowhere else does there exist such a firm of specialists, whose many activities are in evidence in the Engineering markets of the World. Dynamometers and complete Engine Test Plants, Variable-speed Couplings, and Water Coolers are but a few of the specialities of Heenan & Froude—the complete Engineering Specialists whose services are always at your disposal.



VARIABLE-SPEED COUPLINGS

DYNAMOMETERS

WATER COOLERS



TEST PLANTS

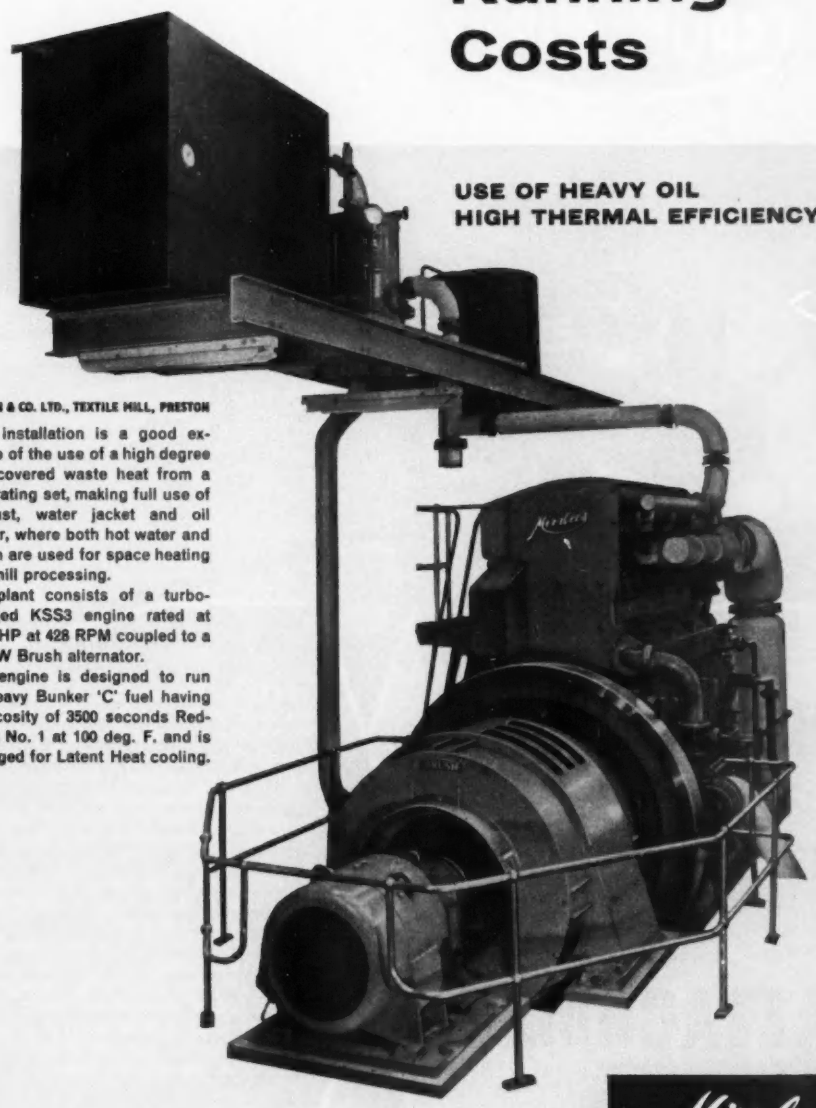
Remember—There is no substitute for experience

ENGINEERING SPECIALITIES BY **HEENAN & FROUDE**

ENGINEERS, WORCESTER

H-W 63

Lower Running Costs



USE OF HEAVY OIL
HIGH THERMAL EFFICIENCY

VERNON & CO. LTD., TEXTILE MILL, PRESTON

This installation is a good example of the use of a high degree of recovered waste heat from a generating set, making full use of exhaust, water jacket and oil cooler, where both hot water and steam are used for space heating and mill processing.

The plant consists of a turbo-charged KSS3 engine rated at 735 BHP at 428 RPM coupled to a 510 kW Brush alternator.

The engine is designed to run on heavy Bunker 'C' fuel having a viscosity of 3500 seconds Redwood No. 1 at 100 deg. F. and is arranged for Latent Heat cooling.

MIRRLEES, BICKERTON & DAY LIMITED · HAZEL GROVE · STOCKPORT · CHESHIRE
Tel: STEpping Hill 1000 (15 lines)
Grams: Mirrlees Telex, Manchester

A member of Hawker Siddeley Industries

IE 44

Mirrlees

diesels

CROWTHORN

HYDRAULIC COPYING ATTACHMENT

This extremely useful attachment is suitable for all Crowthorn Lathes. (The illustration shows the unit fitted to a 10¼in. Centre Lathe).

Particular advantages of the Crowthorn attachment are as follows:-

1. great reduction in machining times.
2. accuracy does not depend on the skill of the operator.
3. attachment is fitted to existing cross slide at rear of lathe. Front tool post can be used in normal way.
4. round models or flat templates can be used as masters.
5. can be used for boring, face copying and normal external machining.
6. a high degree of accuracy is obtained.
7. slow tapers can be machined and radiused forms easily copied.

CROWTHORN ENGINEERING COMPANY LIMITED

Makers of High Class Machine Tools for over half a century

REDDISH · STOCKPORT · ENGLAND

Phone: STOCKPORT 7271-2-3 *Grams: CROWTOOL, REDDISH*

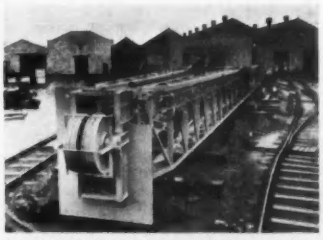
CL 100

starting something?

starting something? . . . like an oil well, perhaps, or a project where you could use specialised knowledge and experience . . . or where, without capital expenditure, you could supplement your own resources with extra Design and Production facilities. It could be a job for The Pickering Group of Companies.

For here, the traditional engineering skills of almost a hundred years of history, are merged with the advanced techniques of the Twentieth Century—techniques in the application of High Vacuum principles to Industrial problems—*the provision of Complete Off-Shore Drilling Equipment*—the production of Metal Evaporation Units, the fabrication of Engine Bedplates, Gearboxes, Cranes and Tanks—and the building of High Vacuum Units for Metal Coating, Decorative Finishes and Optical Blooming. Even in the High Vacuum aspects of Space Research, The Pickering Group has something to offer!

On a contract or sub-contract basis, The Pickering Group of Companies is daily providing a valuable service to many diversified industries. A Technical Consultant Service is available, and your enquiries are invited.



DRILLING RIG STRUCTURE

THE PICKERING GROUP OF COMPANIES

SERVING INDUSTRY IN MANY FIELDS — THE PICKERING GROUP OF COMPANIES — WISHAW · LANARKSHIRE

R. Y. PICKERING & CO. LTD.
Steel Fabrications — Stern Frames — Engine Bedplates — Gearboxes — Crane Structures — Tank Work — Equipment for the Oil Industry.

VACUUM INDUSTRIAL APPLICATIONS LTD.
High Vacuum Equipment — Melting and Sintering Furnaces — Metal Evaporation Units — Vacuum Casting Plant — Control Equipment, etc., etc.

DANIEL VARNEY LTD.
Scientific Instruments.

WOODFIELD PICKERING LTD.
Complete Off-Shore Oil Drilling Equipment.

NETHERTON ROAD · WISHAW · LANARKSHIRE · SCOTLAND

Telephone: *WISHAW 2142 Telegrams: PICKERING, WISHAW

NEW HYDRAULIC COUPLING

ELASTIC DRIVE "MILL" type GIM 3,
units from 0.5 to 10 HP. Patent pending.

GENERAL CATALOGUE ON APPLICATION

SOCIETA GENERALE DELLE MACCHINE "MILL"

Sede Soc.: via V.Monti, 9, Milano.
Uffici: via Priv.Asti, 15, Milano.
ITALIA

Screw-locked milling... AT ITS SIMPLEST & MOST EFFICIENT

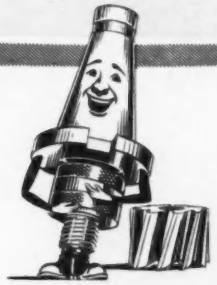
"They've done it again! You can rely on Dormer to turn out the tools for peak performances with the greatest accuracy and the least trouble. Look how easy this is. . . .

DORMER HELI-MATIC ARBORS & SCREWED BORE CUTTERS

This high-efficiency combination simplifies screw-locked milling and achieves the greatest productivity. Ease of assembly, precision in performance, and duration of working life, are the outstanding features of the Heli-Matic equipment.

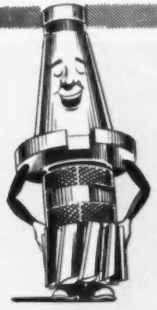
First Stage

Screw on the nut by hand —as far as it will go.



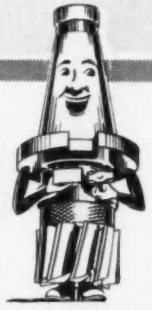
Second Stage

Screw on the cutter to meet the nut—then release by a part reverse turn.



Third Stage

Screw back the nut firmly against the cutter by hand—immediately cutting starts the cutter will lock solidly against the nut, making a rigid tool assembly.



To Release

Apply the spanner to the nut and a few sharp hammer blows will release the nut from the cutter, which can then be screwed off by hand."

You can't go wrong—send for the Heli-Matic brochure giving the full range of Arbors and Cutters.

DORMER

Heli-matic

THE SHEFFIELD TWIST DRILL AND STEEL COMPANY LIMITED
SHEFFIELD **ENGLAND**

DORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

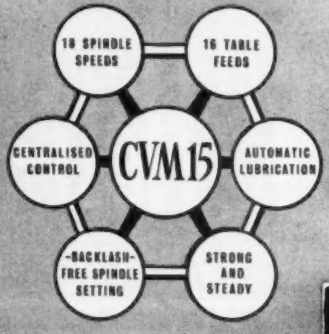
MILL

THOSE SMALLER COMPONENTS

FASTER ON THE NEW CVM 15

OPTIONAL EXTRAS

- SWIVEL MILLING HEAD
- POWER TRAVERSE TO SPINDLE
- BORING FEEDS TO SPINDLE
- RETRACTION OF SPINDLE
- INFINITELY VARIABLE FEEDS
- CYCLE MILLING
- TWO-DIMENSIONAL PROFILING
- AUXILIARY CIRCULAR TABLES
- SIDE MILLING MANDREL AND SUPPORT
- DIAL GAUGES FOR BORING



SPECIFICATION

WORKING SURFACE OF TABLE	54 in. x 16 in.
HEIGHT ADMITTED BETWEEN SPINDLE NOSE & TABLE	MIN. 1½ in. MAX. 24 in.
DISTANCE FROM CENTRE OF SPINDLE TO FACE OF COLUMN	18 in.
SPINDLE ADJUSTMENT	6 in.
SPINDLE DRIVING MOTOR	40 h.p.
SPINDLE SPEEDS: up to 1600 r.p.m.	
THREE OPTIONAL RANGES OF 18 SPEEDS	
RANGE 1.	20 TO 1000 r.p.m.
RANGE 2.	25 TO 1250 r.p.m.
RANGE 3.	32 TO 1600 r.p.m.
TABLE FEEDS: up to	63 ins./min.
FOUR OPTIONAL RANGES OF 16 FEEDS	
RANGE 1.	0·8 TO 25 ins./min.
RANGE 2.	1·18 TO 37·5 ins./min.
RANGE 3.	1·6 TO 50 ins./min.
RANGE 4.	2 TO 63 ins./min.
TABLE RAPID TRAVERSE	100 ins./min.

FOR FULL DETAILS WRITE TO

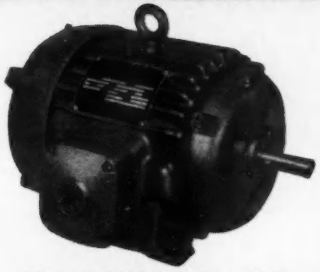
KENDALL & GENT

Phone EAST 3282 GORTON MANCHESTER

K249A

high torque to B·S·D

....and high torque, high slip



TOTALLY-ENCLOSED FAN-COOLED

TYPE 'D'. For duty in atmospheres laden with dust and dirt.

VENTILATED DRIP-PROOF

TYPE 'C'. Drip-proof in any position.

'ENGLISH ELECTRIC' offer

HIGH TORQUE: Types 'D' and 'C' motors.

HIGH TORQUE, HIGH SLIP: Type 'C' motors for high inertia machines such as drop stamps and presses.

- ***Foot, flange and skirt mounted***
- ***Complying with BS 2960***
- ***Class 'E' insulation***

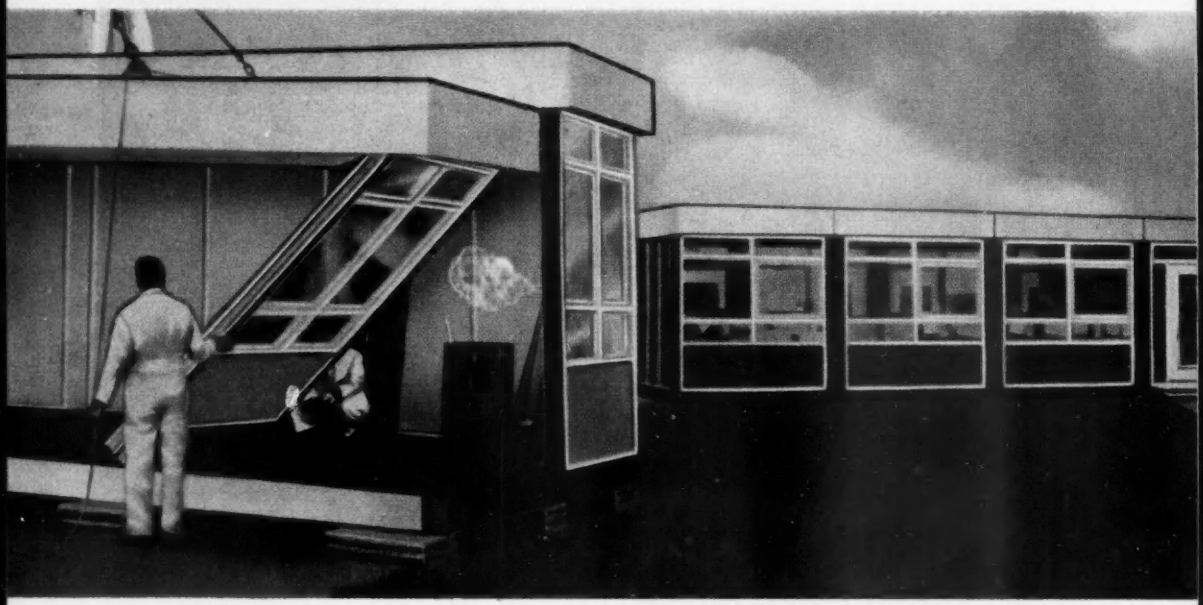
Send for full information to:
Industrial Machines Department,
The English Electric Company Limited,
Phoenix Works, Bradford

'ENGLISH ELECTRIC'
high torque industrial motors

The English Electric Company Limited, English Electric House, Strand, London, W.C.2.

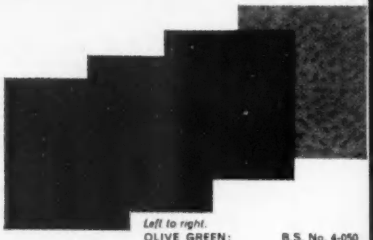
DM.100A

REVOLUTIONARY NEW
Enables finished construction at 4000 sq. ft. of Floor Area Per Day



95% FACTORY BUILT - Terrapin building units are constructed under closely controlled manufacturing conditions from high quality materials. Each Terrapin "Building Unit" (the basis of all Terrapin construction) is completely finished in the factory incorporating interior and exterior decoration, glazing, roof coverings, floor coverings, and electric lighting installation.

A BETTER BUILDING - FASTER - Transported to the building site in folded condition Terrapin "Pack Units" can be erected to form single or multi-span buildings of almost any shape or size faster than by any other known system of construction.



Left to right.

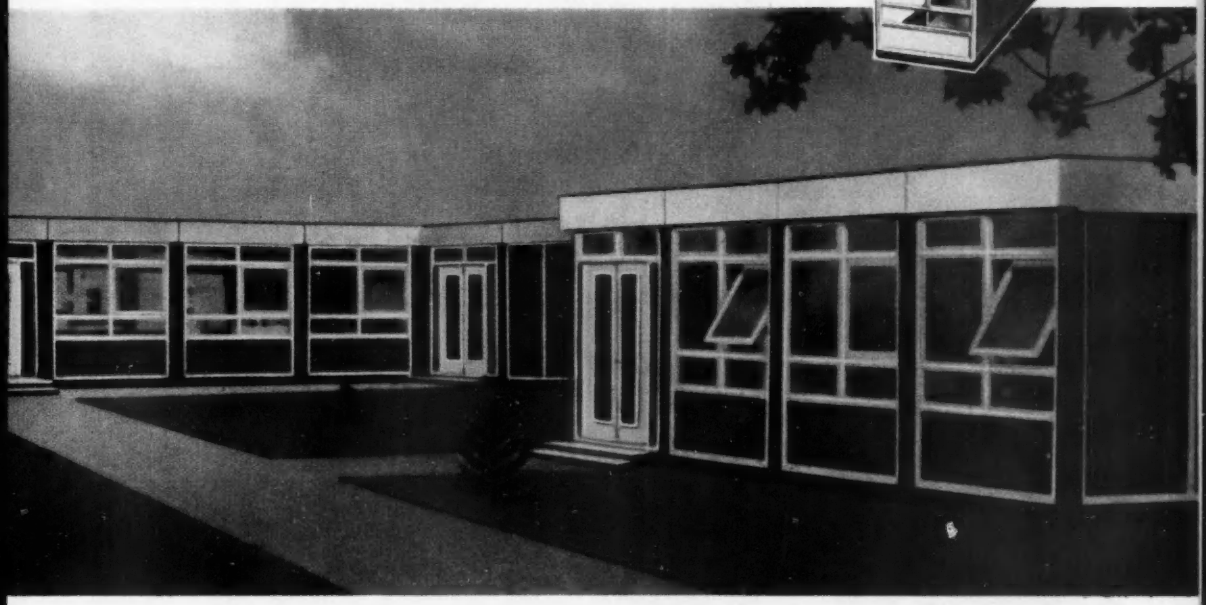
OLIVE GREEN:	B.S. No. 4-050
BALTIC BLUE:	B.S. No. 0-011
PINE GREEN:	B.S. No. 5-061
MUSTARD YELLOW:	B.S. No. 4-056

A QUALITY PRODUCT - High standards of workmanship and materials, backed by rigorous testing and inspection during manufacture, are the hallmark of Terrapin buildings. Proof of their quality and performance is substantiated by an ever increasing demand from all branches of Industry, Commerce and the Social Services.

MOBILITY - As quick and easy to dismantle as to erect, Terrapin "Pack Buildings" can be moved when you like - where you like - and as often as you like - speedily and at extremely low cost.

BUILDING SYSTEM

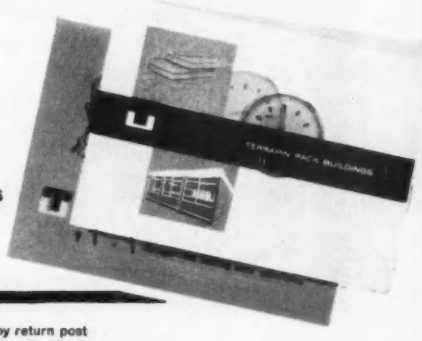
Terrapin pack building units can be used to create modern functional buildings of superb quality. They can be erected end to end and side to side to form buildings of almost any size and any ground plan, faster than by any other known method.



Now 4 External Colour Schemes from which to choose.....

.... in addition to our standard external finish in varnished AFRICAN UTILE HARDWOOD. These new colour finishes are in highly durable, low maintenance textured paint.

A full colour brochure and a copy of the Terrapin price list, which enables you to make up your own preliminary estimate of cost, will be mailed to you by return post. Complete the coupon and post today.



TERRAPIN

" Bring you tomorrows buildings today "

TERRAPIN LIMITED
Haddon House, Fitzroy Street, London, W.1.
Telephone: Langham 0611. Private Branch Exchange.
Telegrams: Terrapin Wesdo London.

Please send me by return post your " Brochure & price list ". (E.3)

Name .....
(Block capitals please)

Company .....

Position in Company .....

Address .....

LAST YEAR GT. BRITAIN CONSUMED

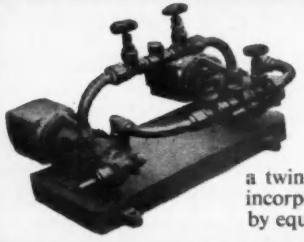
36 1/2

MILLION TONS OF OIL
AN INCREASE OF 10%

VARLEY PUMPS

are handling a larger proportion than ever

a small motorised pump unit



a twin pumping set incorporating stand-by equipment

MOTORISED GEAR PUMPS

VARLEY–FMC LIMITED

(Subsidiary of Food Machinery and Chemical Corporation U.S.A.)

FERRY LANE BRENTFORD MIDDLESEX *Telephone: ISLEWORTH 3922 (6 lines) Telex No. 25371 Telegrams: Paracyclic Brentford Telex*

P.4967

DOWTY

PRECISION MOULDINGS
and GASKETS

in Natural, Synthetic and Silicone Rubbers.
Bonded, P.T.F.E. and Nylon Components.

DOWTY SEALS LIMITED · ASHCHURCH · GLOS.

Member of the Dowty Group

Telephone: Tewkesbury 2271.

MAXIMUM PENETRATING CAPACITY

. . . and not only maximum penetrating capacity . . . but also unsurpassed speed and ease of operation, due to hydraulic pre-selection of feeds and speeds. Capacity is up to 4½″ diameter, in cast iron. There are 22 speeds from 11 to 1450 r.p.m., and 18 rates of feed. These powerful and versatile machines are available in ten sizes, from 5 ft. to 14 ft. spindle radius. Complete details gladly sent on request.

N.B.—Our photograph shows the drilling of rolling mill work chucks at Davy & United Engineering Co. Ltd., Sheffield.

ARCHDALE

JAMES ARCHDALE & CO. LTD.
BLACKPOLE WORKS · WORCESTER
Worcester 27081 (7 lines)

STAVELEY GROUP

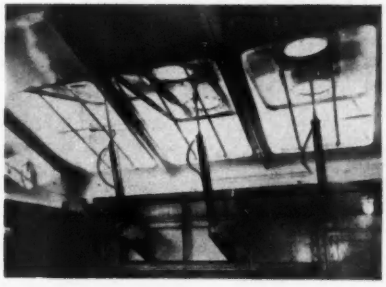
Sole Selling Agents: ALFRED HERBERT LIMITED.

Hydraulic
PRE-SELECT RADIALS

once upon a time.. says Mr. SQUINCH

... the man at Lang Pneumatic invented a

NEWTOMATION



Skylight opening by Lang Pneumatic air equipment in the engine room of 'The City of Lichfield.'

It was better than ordinary Tomations because whereas they were only automatic, and often enigmatic, this invention was driven by air with the greatest of ease. It soon became the greatest air power in the world. You had only to say Lang Pneumatic and you had a complete system to suit practically any job you wanted to do—from jig boring to bottle washing.

And everybody worked happily ever after.

Join up with PNEUTOMATION.® Send ONE sheet of your note paper—sign your name—and we'll send to you details of the pnew way to make work pay. PNEUTOMATION.®

Write to :

Lang Pneumatic Ltd

(ASSOCIATED WITH DESOUTTER BROTHERS (HOLDINGS) LTD)

VICTORY WORKS OWEN ROAD · WOLVERHAMPTON · *Telephone: 25291-2-3* · *Telex 33193*

This is the Steel...

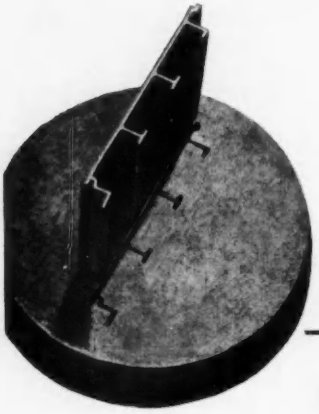
That makes the Die,

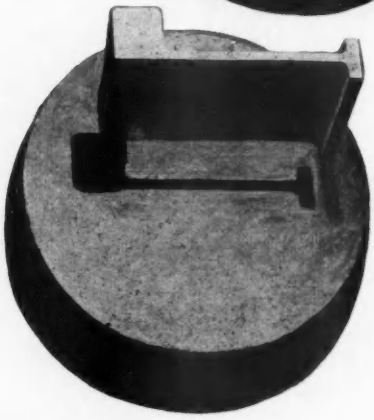
That lasts so long,

That produces more

At lower cost

Photo. by courtesy of The British Aluminium Company Ltd.





ESC

ENGLISH STEEL

ROLLING MILLS CORPORATION LTD

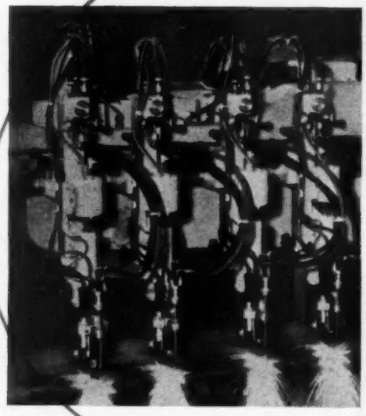
Openshaw Manchester

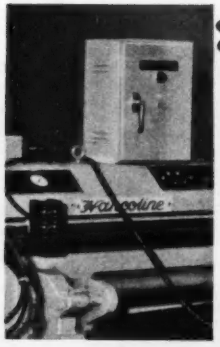
Telephone: Manchester East 1371

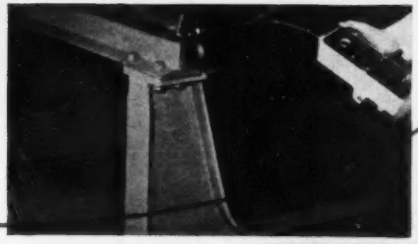
A wholly owned subsidiary of English Steel Corporation Ltd.

PROFILING—FROM

PENCIL DRAWING







HANCOLINE
OXYGEN CUTTING MACHINE
NO TEMPLATES NEEDED!

Just how simple, how labour-saving, how time-saving has oxygen profiling become? You can't know the complete answer until you've seen the electronic Hancoline in action. This special, streamlined machine, the result of 40 years of Hancock leadership in oxygen cutting, traces from a pencil drawing—automatically.
It never needs templates!
Think what a saving that means in production costs and in storage space! The Hancoline uses the same drawing for cuts of different thicknesses, and dimensional inaccuracies can be corrected instantly.

★ **Fitted with Hancock roller drive - no physical contact**
★ **Cut width compensation on tracer head**

The Hancoline is available with 38", 60", 90" and 120" cutting widths

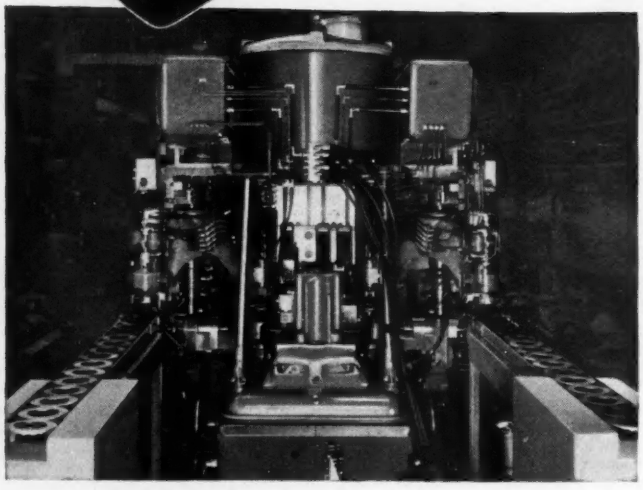
HANCOCK—THE FIRST NAME IN OXYGEN CUTTING

Write for full details

HANCOCK & CO (Engineers) LTD

PROGRESS WAY,
CROYDON, SURREY.
Telephone: Croydon 1908
Cables: Hanco Croydon

The illustration shows the Hancoline with Automatic Height Control Units on the four burners; operated by remote control.



Ryder

does it this way . . .

Ford use the standard RYDER No. 8 VERTICALAUTO with double auto-handling to produce two components per cycle. Here is a system that gets right to the heart of higher overheads, providing the production scope of special equipment on a standard machine.

RYDER VERTICALAUTOS suitably adapted for automatic handling can cut your production costs too.

THOMAS RYDER & SON LIMITED,
TURNER BRIDGE WORKS,
BOLTON, ENGLAND.

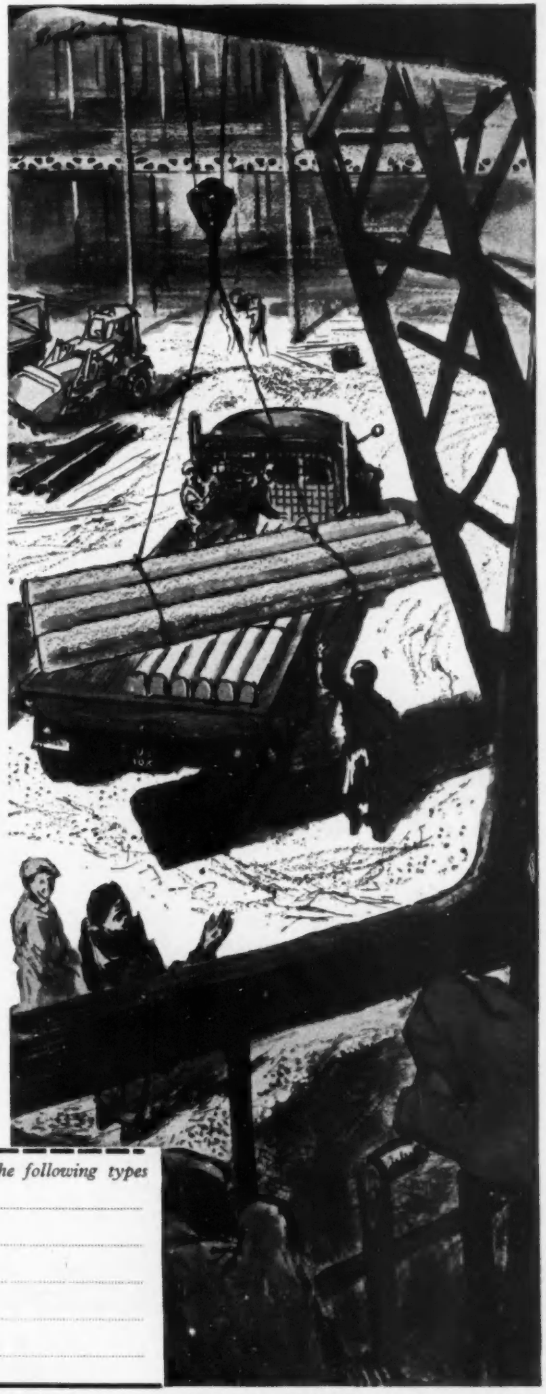
See Ryder about automatics and auto-handling

A BUILDER'S BEST FRIEND IS A FORD ENGINE

Equipment powered by a Ford Industrial engine starts with two major advantages — the heart of it is a tough, hard-working, reliable power-unit built to the most modern designs, and behind it is the famous Ford Service Organisation — a world-wide chain of factory-trained engineers with stocks of genuine Ford parts.

Cranes, Excavators, Dumpers, Loaders, Compressors, Generators, Pumps — all are available with Ford power-units, petrol or diesel.

Please send the coupon below for details of the Ford-powered equipment you are interested in.



FORD

SPELLS POWER

Please send me details of Ford-powered equipment of the following types

Type or class of equipment .....

YOUR FIRM'S NAME .....

For the attention of Mr. .....

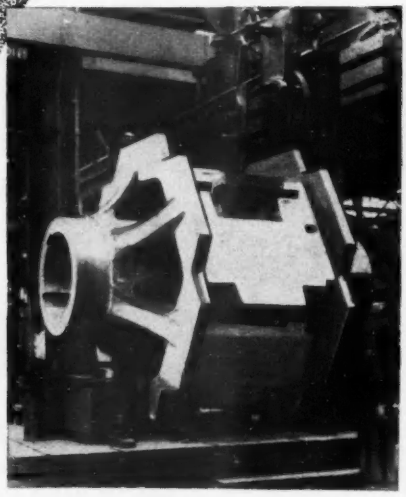
ADDRESS .....

.....

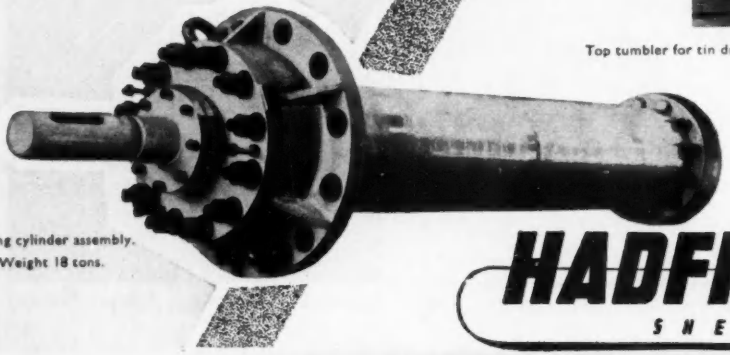
TO: **FORD INDUSTRIAL ENGINE DIVISION** · DEPT. G5b/CR7 · SOUTH OCKENDON · ROMFORD · ESSEX · ENGLAND

THINK OF CASTINGS FIRST

Best quality steel castings have many applications which offer certain economical advantages over other production methods. Before finalising your requirements **THINK OF CASTINGS FIRST** and consult Hadfields . . . . . a name for Steels in **CARBON—LOW ALLOY —STAINLESS—MANGANESE— WEAR RESISTING—HEAT RESISTING STEELS.**



Top tumbler for tin dredging Weight 17½ tons.



Tilting cylinder assembly. Weight 18 tons.

HADFIELDS
SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS SHEFFIELD ENGLAND

the super

POLYBLOC

TRADE MARK

The most efficient

GRAPHITE HEAT

EXCHANGER

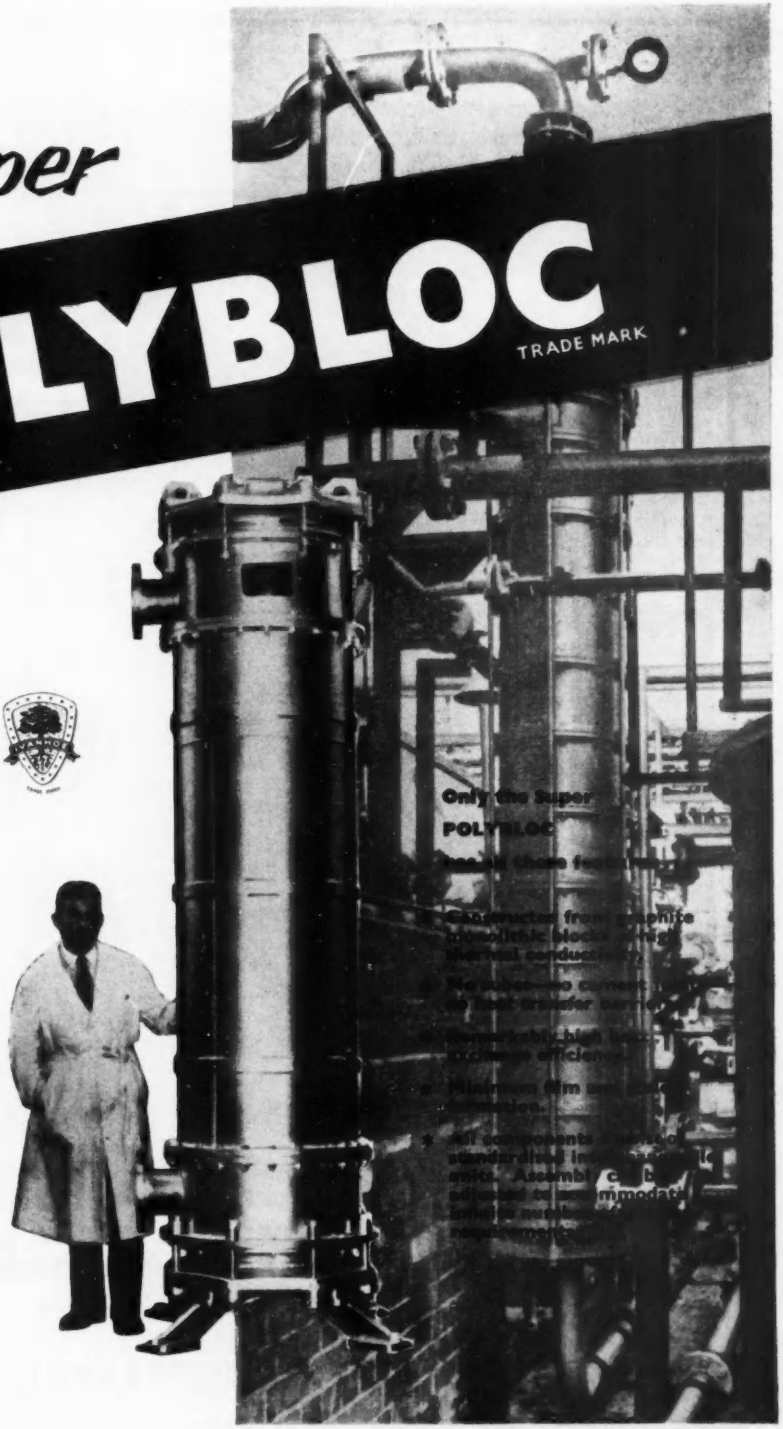
in the world

FOR HEATING

OR COOLING

CORROSIVE

FLUIDS



ROBERT JENKINS
& CO. LIMITED
ROTHERHAM

Telephone: 4201-6 (6 lines)

Coulthard Madison Kipp

THE MODEL 215
GUARDED KIPPCASTER
for fast safe quality pressure diecasting

featuring
the new **SAFETY GUARD**

★ **NO LOSS IN PRODUCTION** ★ **FULLY INTERLOCKED**
★ **QUICK DIE CHANGES . . . GUARD STAYS ON**
★ **APPROVED BY HMI of FACTORIES**

These guards can be fitted to existing machines.

CONSULT
WM. COULTHARD & CO. LTD. DURRANHILL, CARLISLE. 21418

AUTOMATIC SIZING

by MERCER

PNEUMATIC GRINDING MACHINE CONTROL

ONE HUNDRED YEARS OF FINE MEASUREMENT

THOMAS MERCER LIMITED

of St. Albans, Hertfordshire. TELEPHONE ST. ALBANS 55313

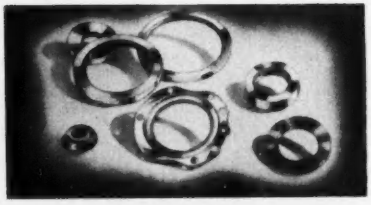
Scottish Agents: J. F. TENNANT LTD., 52 ST. ENOCH SQUARE, GLASGOW ,C.1

NRP 2509

SUPERFECTLY SEALED

Whatever your oil sealing problem there is sure to be a SuPerfect solution. Our many years of practical experience in dealing with oil sealing problems for the motor car industry have resulted in our extensive range of rotary shaft seals, face type seals, hydraulic packings and 'O' rings.

SPECIFY SUPERFECT AND BE SURE



SUPERFECT

OIL SEALS

SUPER OIL SEALS & GASKETS LTD · BIRMINGHAM 30
FACTORY CENTRE · KINGS NORTON · BIRMINGHAM 30 Tel: KINGS NORTON 2041

KEELAVITE
Hydraulics

HYDRAULIC POWER PACKS

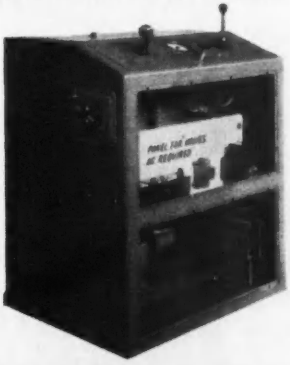
IN THEIR NEATEST FORM

THE 'MIDGET'
THE 'MINOR'
THE 'MAJOR'
THE 'MIGHTY'

Keelavite power packs provide a range of self-contained hydraulic power units suitable for many widely differing industrial applications. A large number of pumping capacities are available. All packs are so designed that the valves most suitable for the customer's requirements can be fitted. Standard units from the enormous Keelavite range are used.

introducing an entirely new
Power Pack of which you will want details

The KEELAPACK



A desk top console which houses the complete hydraulic system. Hydraulic and electrical controls neatly contained in minimum space. Custom built from standard components.

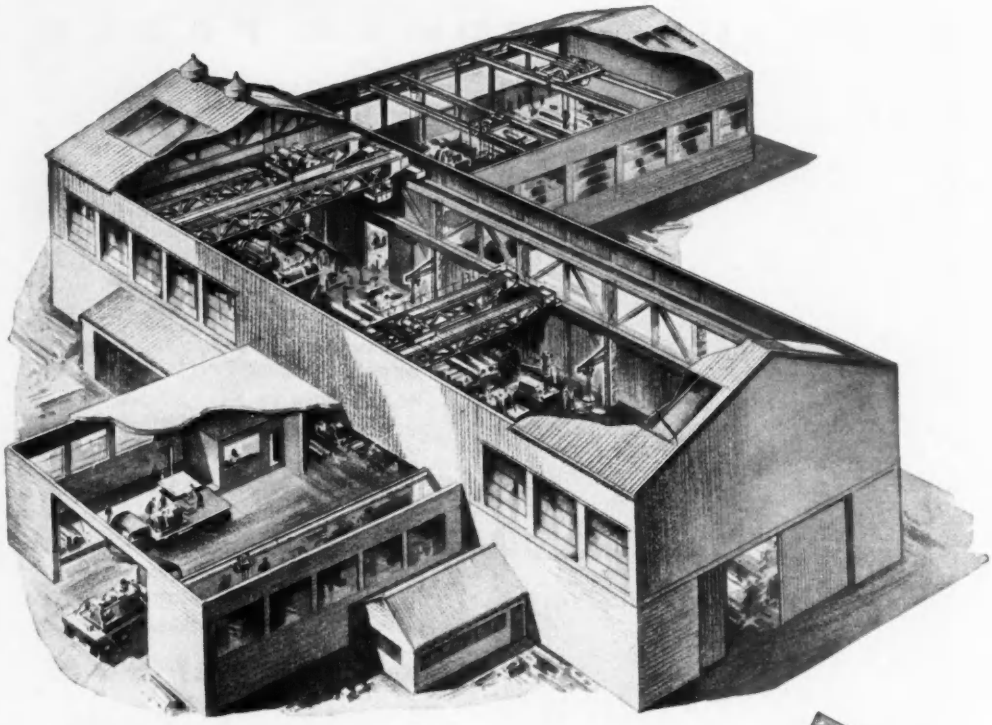
For full details write to

KEELAVITE
Hydraulics

KEELAVITE HYDRAULICS LTD
ALLESLEY · COVENTRY · TEL: MERIDEN 441

KEELAVITE COMPLETE HYDRAULICS
– a complete range of units
– thirty years of hydraulic experience
– and a service that means success

Plan with WHARTON...



By giving consideration in the planning stage to the lifting requirements and handling problems the plant engineer or architect can eliminate the hazards of last minute decisions.
The Wharton engineer is available at all times to collaborate with those concerned in the development of new projects.
The range of Wharton products extends from hand pulley blocks of half ton capacity, electric chain blocks, electric hoists and overhead hand operated cranes to overhead electric cranes of up to a maximum capacity of 200 tons.

This Catalogue describing Cranes and Hoists may be of help—if so write for it today.

THE WHARTON CRANE & HOIST CO. LTD.
REDDISH - STOCKPORT - ENGLAND

Phone : Heaton Moor 2227. Grams : "Gallant, Manchester." Code : Western Union.

LONDON: Lincoln House, 296/302 High Holborn W.C.1. Phone: Chancery 7911. Grams: Chancery 7911.
SCOTLAND and NORTHERN COUNTIES: Gordon Baxter & Co. Ltd., 25 Blythswood Square, Glasgow C.2. Phone: Central 6917/8. Grams: Gorbaxco, Glasgow.
MIDLANDS: A. R. Holland & Son, 89 Cornwall Street, Birmingham 3. Phone: Central 1457. Grams: Central 1457, Birmingham.
SOUTH-WEST: R. C. Collins, 48 Westbourne Road, Penarth, Glamorgan. Phone: Penarth 58527. Grams: Penarth 58527.
NORTHERN IRELAND: General Engineering Products Ltd., 7/9 Great Patrick Street, Belfast. Phone: Belfast 23743. Grams: Belfast 23743.
REPUBLIC of IRELAND: Charles Nolan & Co., 2 Parker Hill, Lower Rathmines Road, Dublin. Phone: Dublin 93510. Grams: Dublin 93510.
CANADA: Marshall Equipment Co. Inc., P.O. Box 28, 61 O'Connell Avenue, Dorval Station, P.Q. Phone: Melrose 1-3528. Grams: Marquipco, Montreal.
Gordon Russell Ltd., 1661 West Fifth Avenue, Vancouver 9, B.C. Grams: Rustle.
Mumford, Medland Ltd., 576 Wall Street, Winnipeg, Manitoba. Phone: 37-180, 37-187-188-189. Grams: Mandem.
SOUTH AFRICA: Kenneth Ray Ltd., P.O. Box 5662, 34 Ameshoff Street, Braamfontein, Johannesburg. Phone: 44-2168. Grams: Gemray.

REPRESENTED IN PRINCIPAL COUNTRIES THROUGHOUT THE WORLD

A revolutionary concept of submerged arc welding
FULLY AUTOMATIC WELDING GUIDED BY HAND....

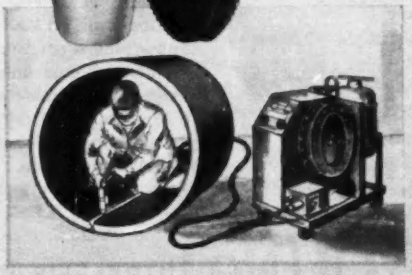
"IDEALARC"
TRADE MARK

mechanized
SQUIRT WELDER

.....TWICE as fast as manual welding

The "Squirt" offers you the combined advantages of automatic submerged arc welding with the versatility of manual electrodes. For the first time a semi-automatic welder has automatic travel, flux and wire feed mechanisms in addition to controlled arc voltage and welding current. *Simplicity itself to operate*—just set the current and voltage, preset the travel speed of the gun, line up the joint, place the gun in position and push the trigger.

THE RESULT—HIGH SPEED HIGH QUALITY SUBMERGED ARC WELDS



IMPROVES QUALITY

Consistent welds equal to those made with fully automatic equipment, and approved by Lloyds. The "Squirt" with "Idealarc" alloy fluxes welds all alloy steels.

REDUCES COSTS!

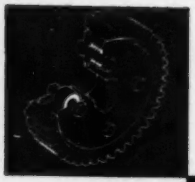
High Operating Factor, the automatic feed of Electrode and flux enables continuous welding of hundreds of feet. It gives deeper penetration, using minimum weld metal, the automatic travel guarantees consistent weld eliminates scarfing and reduces waste. It has low flux consumption and a versatility of application.

For further details write to:—

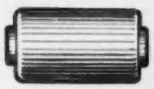
ARMCO LIMITED
SOLE DISTRIBUTORS IN THE U.K. FOR

76 GROSVENOR STREET,
LONDON, W.1. *Tel: HYDe Park 9111*

THE LINCOLN ELECTRIC COMPANY · CLEVELAND · OHIO · USA
the world's largest makers of arc welding equipment

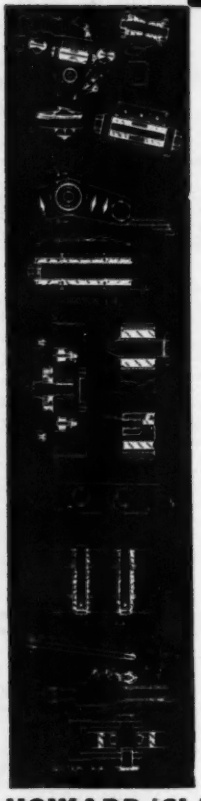


MORE AND MORE DAY BY DAY



CLAYFLEX

HARRISFLEX



FLEXIBLE BEARINGS SERVE INDUSTRY

The ever increasing popularity of Clayflex and Harrisflex bearings can only be traced to the confidence engineers, the world over, place in these well proved products.

The pressure and chemically bonded Clayflex bearings are supplied in forms to suit standard and specialized applications. Outstanding in this range is the B.P. type bearing which has been specifically designed to give positive axial control under high radial loadings, and to cater for high conical deflections.

Harrisflex controlled flexible bearings are being used for an ever increasing range of applications, where space and weight restrictions are involved. In addition these units offer advantages in their ease of assembly on production lines.

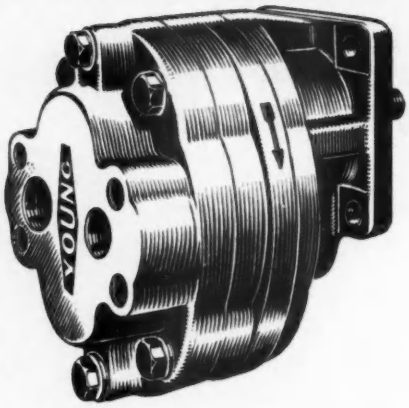
For further information concerning these products, please ask for the appropriate technical literature. The long experience of our Technical Staff is at your disposal to give advice and submit drawings for your particular application.

HOWARD CLAYTON-WRIGHT LTD.

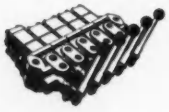
WELLESBOURNE **WARWICK**

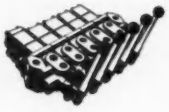
Telephone: WELLESBOURNE 316

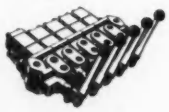
Telegrams: 'CLATONRITE' WELLESBOURNE



TOP PERFORMANCE AT TOP PRESSURE







. . . because, throughout the range of Young Hydraulic Pumps, the exclusive cheek plate design gives maximum operating pressure with minimum wear. This precision made, heavy duty range includes pumps from 12.5 to 30 g.p.m. at 1,000 r.p.m. Precision is a key factor in Young Hydraulic Valves too, and the design enables them to be built up into composite banks. Young Valves, giving finger tip control at all lever positions with no load drop—even when several cylinders are used simultaneously, are available from 15 to 45 g.p.m. at operating pressures up to 2,000 p.s.i. For full details of the Young range of equipment, write now under ref. E.D.4.

YOUNG HYDRAULIC PUMPS AND VALVES

at heart

JOSEPH YOUNG & SONS LIMITED · KAY STREET BOLTON · LANCASHIRE

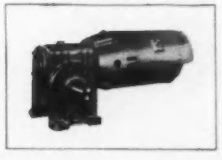
Telephone: Bolton 21431/2 Telegrams: Hydraulics Bolton

YG.4.

Vertical or horizontal, streamlined or functional

THE INCREDIBLY VERSATILE VERSO

This new Holroyd 2½" centres motorised worm gear speed reducer has been designed to meet the need for a self-contained drive suitable for continuous use, and one which will look right in any surroundings. No matter what the application, it is possible to select from its variety of assemblies and mounting positions, an arrangement which makes it appear an integral part of the surrounding machinery, and *not* an added afterthought. The Verso has all the famous features of Holroyd reliability and high efficiency. Centrifugally cast Holfos wormwheel; casehardened and profile ground alloy steel worm; ball bearings throughout; rigid cast iron casing and oil bath lubrication requiring no attention over long periods. Output speeds are from 14 to 300 rpm. Output torques up to 750 lb. ins. Standard Motors from ¼ up to 2 hp. *Please write for catalogue V.60 which gives further technical information.*

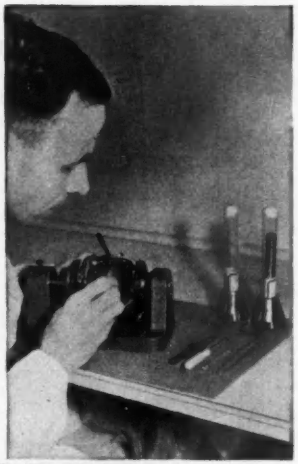


Holroyd

JOHN HOLROYD & CO LTD · MILNROW · ROCHDALE · LANCASHIRE

CRC P8

FOUR DECADES of PROFITABLE ASSOCIATION between HOFFMANN & SPERRY



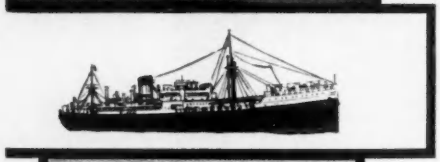
Assembling the Gyro Rotor for a C.L.2 Gyrosyn® Compass. Note the dustproof dispensers containing the bearings.

HOFFMANN... THE PEOPLE INTERESTED IN SPERRY STANDARDS

Navigators of ships and aircraft, each vitally concerned to achieve the safe and timely arrival of their craft, put their faith in Sperry compasses and instrumentation. HOFFMANN BEARINGS, fitted extensively to Sperry instruments, help them to function consistently and accurately to Sperry standards.

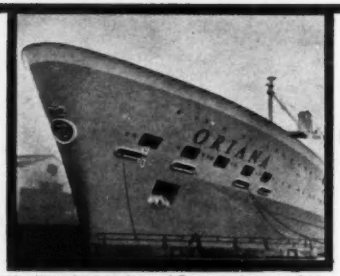
GLOBAL ACCURACY

Like many other well-known civil and military aircraft, the Handley Page Dart Herald Branch Liners ordered initially by B.E.A. and Jersey Airlines, rely extensively on Sperry equipment for automatic flight control and instrumentation, the latter including Gyro horizons and Gyrosyn® compasses employing Hoffmann Bearings. The trouble-free performance of these instruments was demonstrated in the most practical manner by the prototype and first production aircraft respectively in four recent demonstration tours to India, South America, Australasia and West Africa. Sperry Gyrosyn Compasses have, for many years, depended on Hoffmann Bearings for long life, accuracy and reliability.



35,000,000,000 REVS

The record of Port Line's M.V. Port Fairy, 8,406 tons, includes 65 round voyages between U.K. and New Zealand in 32 years, guided by a Sperry Mark VIII Gyro Compass. Since 1943 the 51 lb. weight of the compass rotor has spun steadily at 6,000 r.p.m. upon its HOFFMANN BEARINGS and to date has completed more than 35,000,000,000 revolutions. It is still spinning, trouble free, and accurate upon those same HOFFMANN BEARINGS.



MAIDEN VOYAGE

T.S.S. Oriana, P & O – Orient Lines 42,500 tons luxury liner, sailed on her maiden voyage to Australia, New Zealand, and the Pacific coast of U.S.A., following a course set by a Sperry Mark XIV Gyro Compass. This Compass provides the heading reference for the gyro-hydraulic automatic steering-control, the direction-finding system, radar installations, and several compass repeaters. These include an enlarged-scale steering repeater, two bearing repeaters on the Bridge wings, and a repeater in the steering-gear flat. Three out of four of the World's merchant ships are set upon their courses by Sperry Gyro Compasses, the majority of which employ Hoffmann Bearings.

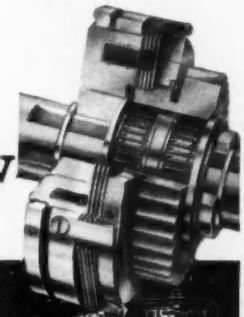
Illustrations by courtesy of Sperry, Handley Page, Port Line and P & O – Orient Lines.

Manufacturers of ***BALL AND ROLLER BEARINGS***

HOFFMANN

THE HOFFMANN MANUFACTURING CO. LTD., CHELMSFORD, ESSEX. Telephone: Chelmsford 3151. Telex No. 1951

for stop...
go...
fast...s-l-o-w
machining



Electromagnetic Multiple Disc CLUTCHES

Electromagnetic Multiple Disc Clutches have proved their efficiency and reliability on a wide variety of machines. Time loss is minimised during changeover stops. Work spindle speed can be varied over a wide range at constant power. Ratios of feed-drive speed to rapid-motion speed in excess of 1:50 are easily obtained.
These Clutches facilitate special production such as automatic machining of a wide variety of work-pieces.

These advantages mean much to the user:

* **Unit unaffected by oil.**
* **No adjustment required at any time.**
* **Small dimensions at high torques.**
* **Low energy consumption through efficient flux utilization.**
* **For torque transmission over very wide range.**

Our Electromagnetic Multiple Disc Clutches are available in various designs.

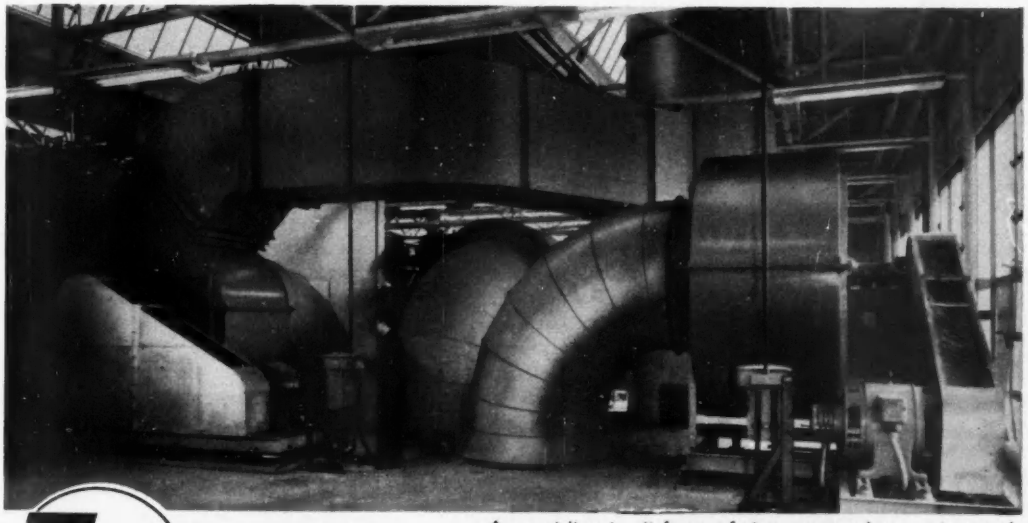
cut non-productive time to a minimum

Siemens-Schuckert (Great Britain) Ltd

FARADAY WORKS · GT WEST ROAD · BRENTFORD · MIDDLESEX

Telephone: ISLeworth 2311 · Telegrams: Siemensdyn Brentford, Hounslow · Telex No. 25337

Smee s 5100



Industrial Fan & HEATER CO. LTD.

As specialists in all forms of air treatment let us advise and quote you for all fan work, dust and fume extraction plant, air conditioning and space-heating equipment.

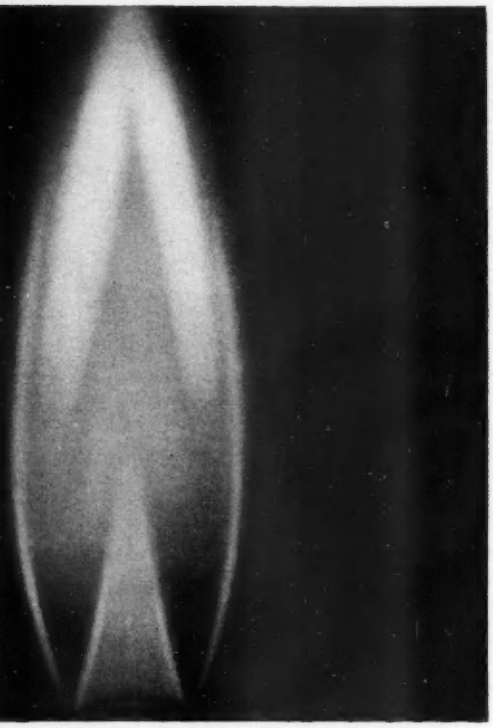
"AIRFLO" WORKS BIRMINGHAM, 11

Phone: Birmingham VICtoria 2277

also at: LONDON, MANCHESTER, SWANSEA

A MEMBER OF THE SIMMS GROUP OF COMPANIES

hot hot hot hot



Where seals and gaskets are required to remain fully efficient over long periods at exceptionally high temperatures, Silastomer* silicone rubber supplies the complete answer.

but never bothered

Silastomer remains fully serviceable at temperatures up to 250°C, where organic rubbers char and melt, and certain grades are available for intermittent use at temperatures as high as 300°C. Nor do extremes of cold effect its properties: Silastomer is still serviceable at —70°C.

The thermal stability of Silastomer silicone rubber is combined with excellent retention of dielectric strength, chemical inertness, good water repellency and great resistance to weathering and oxidation. Silastomer is non-adhesive and most grades can be used for applications where physiological inertness is required. Products made from Silastomer are available from many rubber manufacturers, whose names will be supplied by any Midland Silicones branch office.

**Silastomer is the registered trade name of a comprehensive range of silicone rubbers manufactured and marketed by*

(MS)

MIDLAND SILICONES LTD ***first*** *in British Silicones*

(Associated with Albright & Wilson Ltd and Dow Corning Corporation)

68 KNIGHTSBRIDGE · LONDON · SW1 · TELEPHONE: KNIGHTSBRIDGE 7801

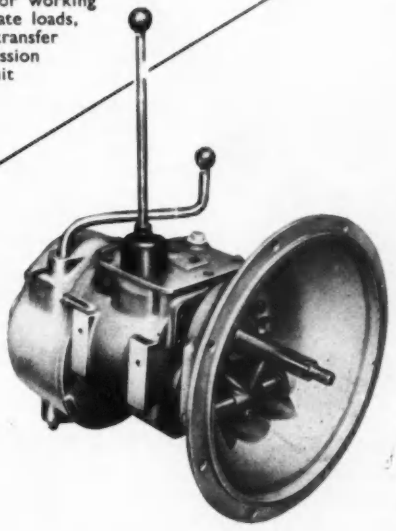
Area Sales Offices : Birmingham, Glasgow, Leeds, London, Manchester
Agents in many countries

MSR IC

MAKE THE *Most*

40M. and CM. 3-Speed & Reverse constant mesh Gearboxes with transfer units, six forward speeds down to 13.76:1 in bottom gear and two reverse speeds. Ratios selected to give two 3-Speed Gearboxes in one. In high gears, a transmission available for working on good surfaces with moderate loads, and engagement of low transfer gears alters the transmission characteristics to suit heavy loads and bad going

OF YOUR *Horsepower*



P.R. MOTORS LIMITED
ALDBOURNE ROAD, COVENTRY
Telephone: 25382/3/4

THE SECOND

Engineering Materials and Design

EXHIBITION & CONFERENCE

13-18 NOVEMBER 1961

EARLS COURT, LONDON

Engineering designers must keep abreast of the latest developments in materials and methods. Because it displays the widest variety and newest examples of components, materials and design, *The Engineering Materials and Design Exhibition* provides an unrivalled source of information. New properties new uses, new design trends . . . all evidence the way in which industrial research is meeting increasing demands. On the stands and at the conferences, the occasion also provides a unique opportunity for the interchange of ideas and reveals many new ways of using materials to the best advantage.

Exhibits include:

Acid resisting materials : Alloys : Anodes and salts : Anti-friction metals : Asbestos fabrics : Bearings : Belting : Beryllium : Brake linings : Castings : Ceramics : Compressed wood-fibre mouldings : Conduits : Corrosion resisting materials : Fibre Glass : Hard facing materials : Heat resisting materials : Hose : Insulators : Metal coatings : Plastic mouldings : Polyester resins : Rubber mouldings : Wire

Subjects and Speakers at the Conference ★ include:

SUBJECT	*SPEAKER*
Design Problems with Bluebird	L. H. Norris and K. W. Norris, *Norris Bros.*
Organisation of a Materials Department	F. C. Carpenter, *Smiths Aircraft Instruments Limited*
Metallurgy applied to the Selection of Metals	D. Birchon, *Royal Naval Scientific Service*
Elastomers in Engineering	D. A. Smith, *The National College of Rubber Technology*
Recent Developments in Insulating Materials	J. Wainwright, *The English Electric Co. Ltd.*
Steels for the Design of Low Temperature Equipment	E. Gill, *International Nickel Co. (Mond) Ltd.*
Plastic Coatings	N. Vinson, *Plastic Coatings Ltd.*
Influence of Corrosion on the Design of Chemical Plant	E. Warde, *Henry Wiggin & Co. Ltd.*

Sponsored by the Financial Times
and Engineering Materials and Design
★ *Full details of exhibition and conference lectures from:*
INDUSTRIAL AND TRADE FAIRS LIMITED
Commonwealth House : New Oxford Street
London WC1
CHAncery 9011

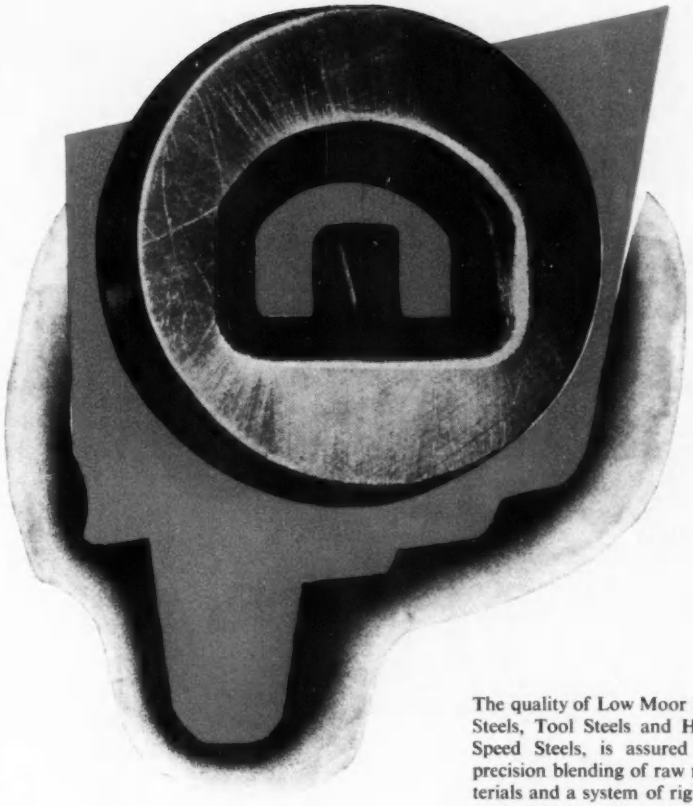
VISIT THE INTERNATIONAL

Factory Equipment Exhibition

Earls Court

AT THE SAME TIME

where resistance to wear and tear is important



The quality of Low Moor Die Steels, Tool Steels and High Speed Steels, is assured by precision blending of raw materials and a system of rigidly controlled conditions at all stages. Each Steel is supplied in the fully annealed condition for easy machining.

the
STEEL
is
LOW MOOR's

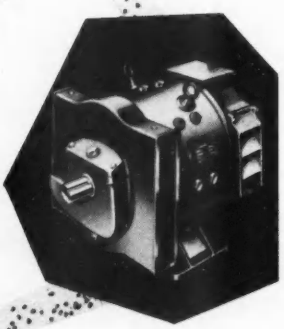
THE SECOND
ENGINEERING MATERIALS &
DESIGN EXHIBITION
November 13-18 Earls Court
Stand B.16

For details of Stainless, Alloy and Special Steels, also Electrical Magnetic Iron, contact—
LOW MOOR ALLOY STEELWORKS LTD. - LOW MOOR - BRADFORD
Telephone: 77331 (9 lines)
For Extrusions contact: LOW MOOR FINE STEELS LTD.

Powney/S. 17

SOLUTION TO D.C. MOTOR PROBLEMS = E.P.E. Q.E.D. *phone STE

E.P.E. thrive on solving D.C. motor problems—have done for years.
We can supply D.C. motors and generators of any enclosure—at a very REASONABLE PRICE.



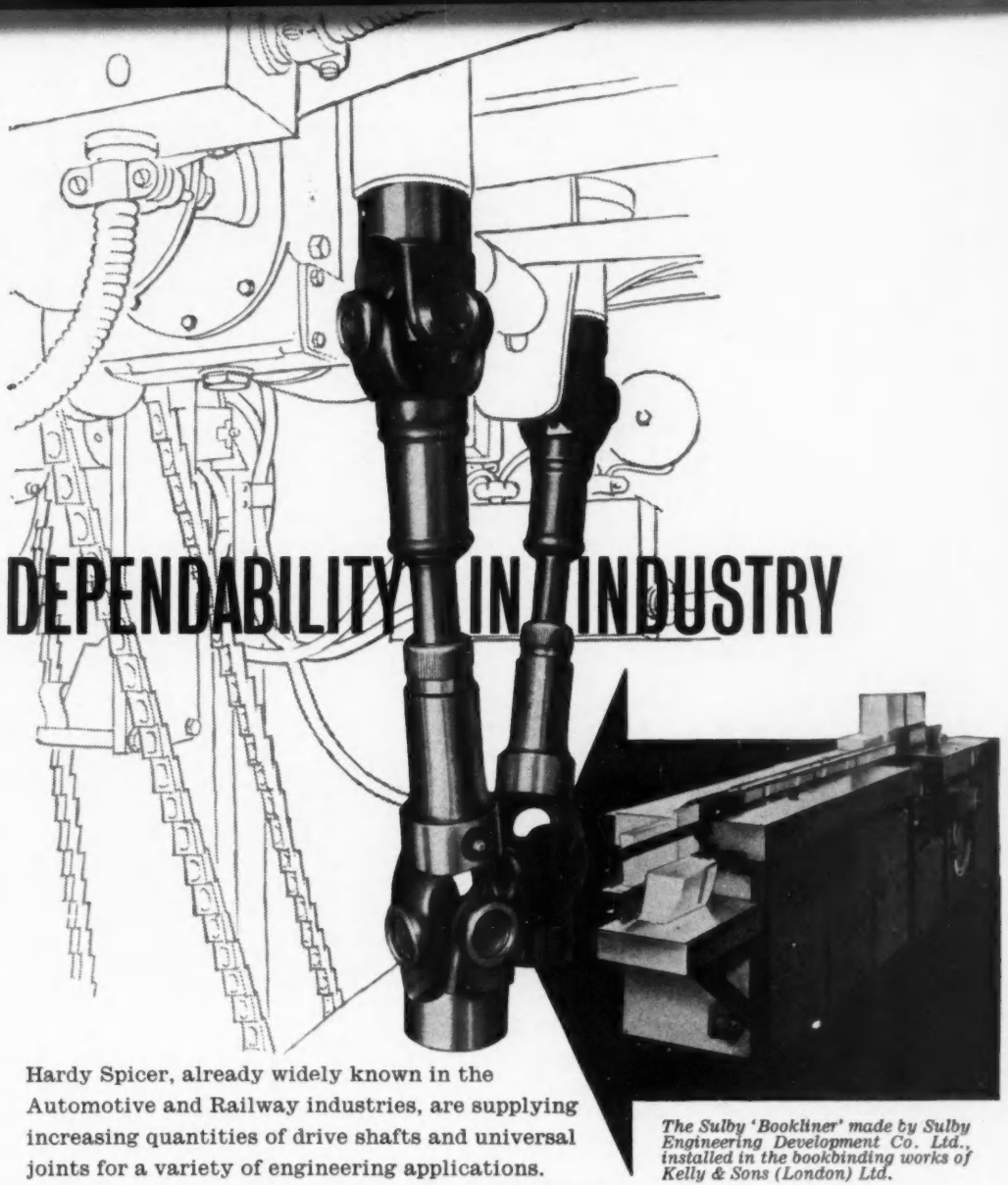
E·P·E

THE ELECTRICAL POWER ENGINEERING Co. (B'ham) LTD
E·P·E Works, Bromford Lane
Birmingham 8

* STE 2261

London Office: 421, Grand Buildings, Trafalgar Square, W.C.2. Phone: WHitehall 5643 & 7963

DEPENDABILITY IN INDUSTRY



Hardy Spicer, already widely known in the Automotive and Railway industries, are supplying increasing quantities of drive shafts and universal joints for a variety of engineering applications. Typical of these are the two universal-jointed shafts illustrated here, used in this case to drive the feed conveyor in a "Bookliner" book-binding machine.

The Sulby 'Bookliner' made by Sulby Engineering Development Co. Ltd., installed in the bookbinding works of Kelly & Sons (London) Ltd.

HARDY SPICER

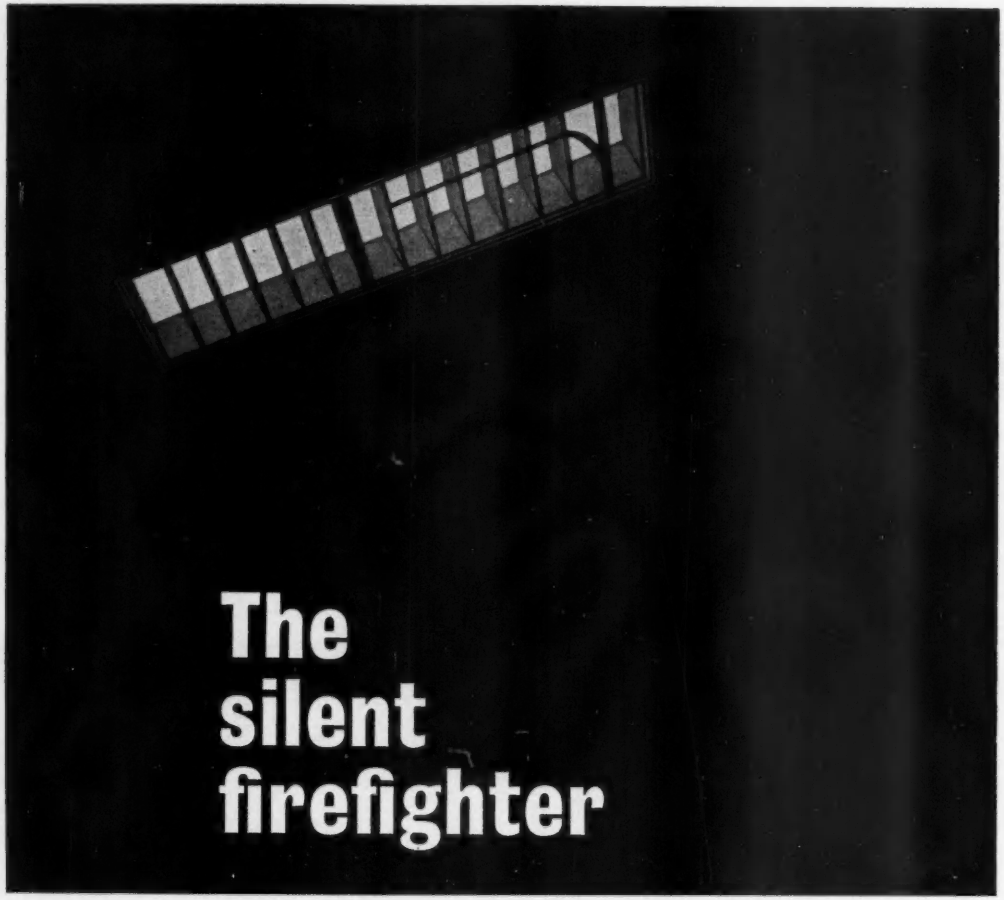
PROPELLER SHAFTS

HARDY SPICER LIMITED

CHESTER ROAD · ERDINGTON · BIRMINGHAM 24 · TEL. ERDINGTON 2191 (18 LINES) · TELEX 33414

ENGINEERING DIVISION OF BIRFIELD LIMITED

Product of the Birfield Group



The silent firefighter

This fire ventilator saved a plant worth £3,500,000
It could well save yours.

As any fire chief will tell you, fire in an unventilated area quickly produces choking, superheated smoke and fumes—conditions which keep firefighters out of the building and make effective firefighting virtually impossible. Perforation of the roof is the only remedy, but this is a hazardous operation which often endangers the life of the fireman.

The Colt Dual Purpose Ventilator has a special device that's acutely sensitive to heat. It opens *automatically* at a pre-determined temperature, releasing smoke, heat and fumes, keeping the fire localised. Firemen can enter the building, find the seat of the fire and extinguish it—with minimum damage to plant and equipment.

Colt dual-purpose ventilators have the added advantage that under manual control they can be used for normal plant ventilation and provide excellent day-to-day working conditions.

Widespread adoption by industry is proof of managerial faith in the silent firefighter.

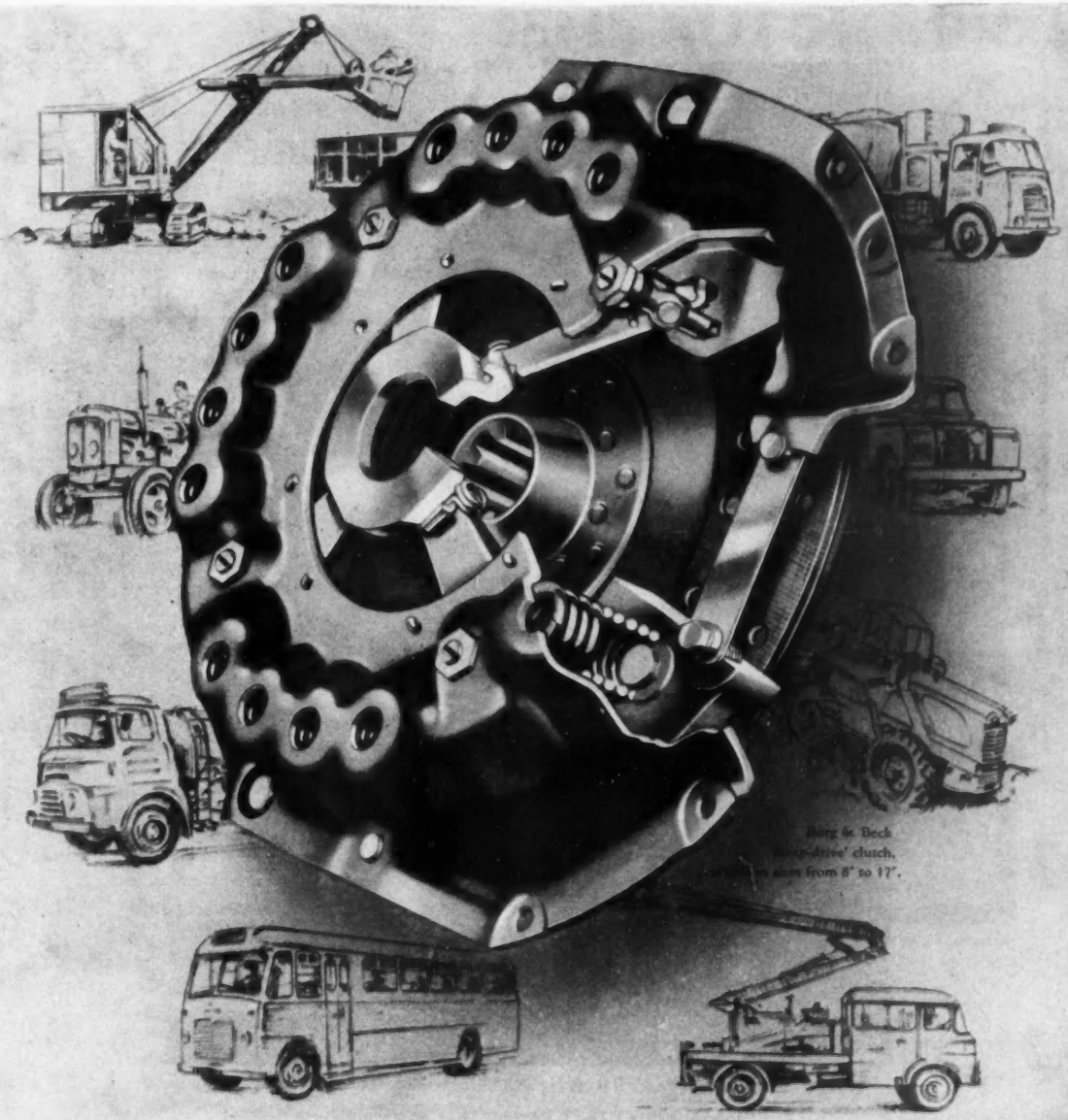
COLT

Dual-Purpose Ventilators

Automatic fire protection—day-to-day controlled ventilation.

For information, write to Dept. 89: COLT VENTILATION LIMITED, SURBITON, SURREY. ELMBRIDGE 0161

THE MODERN TREND DEMANDS...



Borg & Beck
...-drive' clutch,
... sizes from 8" to 17".

BORG & BECK CLUTCHES

LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

REGD. TRADE MARK. BORG & BECK

ONE OF THE
AUTOMOTIVE
PRODUCTS GROUP

ALLEN

CENTRIFUGAL PUMPS

500 to 100,000 gallons per minute
Heads up to 600 feet

MIXED-FLOW PUMPS

500 to 120,000 gallons per minute
Heads from 20 to 70 feet

AXIAL-FLOW PUMPS

2,000 to 120,000 gallons per minute
Heads up to 25 feet

Vertical or horizontal designs to suit all requirements

Above: Twelve out of thirty-six ALLEN horizontal pumps at the Pitsford pumping station of the Mid-Northamptonshire Water Board.

Left: A 31,000 gallons per minute 40-in./38-in. ALLEN vertical double-suction pump for power station circulating water.

W. H. ALLEN SONS & COMPANY LTD · BEDFORD · ENGLAND

Telephone: Bedford 67400. *Telegrams:* Pump Bedford Telex (*Telex No. 82100*)

Specialists in complete Pumping Plant installations

THE WORTHWHILE SEMI-AUTOMATIC for REAL PRODUCTIVITY

CO_2

-the New ROCKWELD Comet MARK II

Full technical data on request

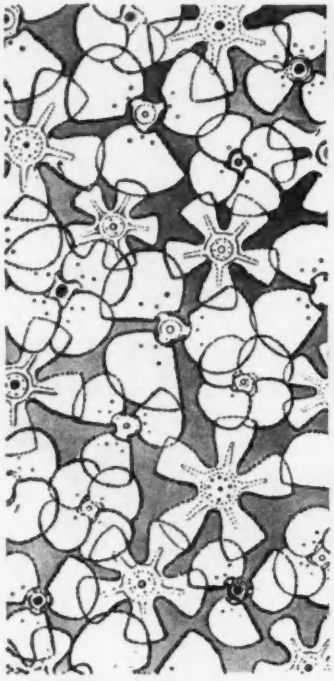
Illustrating Wire Cross-section

The Comet at 600 amps. provides the highest productivity of any CO_2 semi-automatic on the market, a low hydrogen deposit and no porosity, even on heavily rusted plate. The very high currents are made possible by the special flux-intercalated-wire which provides an even distribution of flux over the cross-section of the wire, which in turn gives droplet protection during transfer across the arc. The Comet Mark II can utilise existing AC/DC power packs.

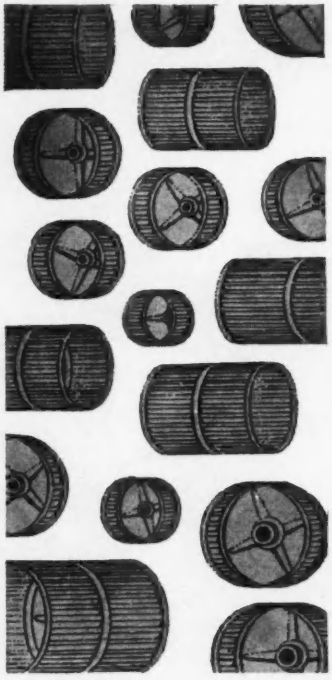
ROCKWELD LTD

COMMERCE WAY · CROYDON · SURREY · Telephone: CROYDON 7161

PROPELLER FANS?
YES, SIR!
BIGGEST RANGE
IN THE COUNTRY



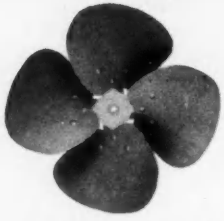
AIROTORS?
YES, SIR!
BIGGEST RANGE
IN THE COUNTRY



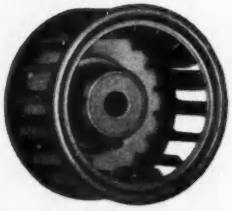
BOFFINS?
YES, SIR!
BIGGEST BRAINS
IN THE COUNTRY

The world-famous TORRINGTON air-impellers are now made and sold by SMITHS.
SMITHS offer the widest range of airotors and propeller fans in this country, and can assemble and deliver promptly from a wide range of tooled stock components. SMITHS Technical Advisory Service puts at your disposal the unrivalled knowledge and experience of both great organisations.

SMITHS
TORRINGTON
AIR IMPELLERS



PROPELLER FANS
From 3" to 24" diameter, either rotation, in a variety of pitches. Light, rigid, quiet, efficient.



AIROTORS
From 1½" to 11" diameter, available in steel or aluminium. In widths from ⅝" to 11".

Write to SMITHS for illustrated literature and technical information. SMITHS engineers will be particularly interested in helping to develop new air-moving applications.

S. SMITH & SONS (ENGLAND) LIMITED, AIR IMPELLER DEPARTMENT, WITNEY, OXON. TELEPHONE: WITNEY 678

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *SYNTHETIC SEMICONDUCTING DIAMONDS*

Semiconducting diamonds are extremely rare in nature, but it is now reported that they can be produced with comparative ease in the laboratory. To make the diamonds semiconducting, impurities such as boron, beryllium, or aluminium are added to the mixture of graphite and catalyst used to make synthetic diamonds. The mixture is subjected to pressures of about 1,000,000 psi and to temperatures above 2000°F. Under these conditions, the diamonds form with concentrations of 1% or less of the desired impurity and have electrical conductivities in the semiconducting range. All the semiconducting diamonds so far produced have been of the *p*-type, but a search for *n*-type diamonds is continuing. Semiconducting diamonds prepared with boron are of a blue colour, with shades ranging from a pale blue-white to a deep blue-black, depending on their boron content. Semiconducting diamonds found in nature are also sometimes blue. In this connection, it is interesting to note that one of the most famous natural blue-white diamonds is the Hope diamond and, although its conductivity has not been measured, its colour suggests that it is probably a semiconductor.

It is also reported that semiconducting borazon (a cubic form of boron nitride, with a structure very similar to that of diamond and equally hard) has been made successfully. Both *p*-type and *n*-type crystals can be produced in borazon, and one type can be grown onto a "seed" of the other type to form *p-n* junctions. Tests on these junctions show that they act as rectifiers. Beryllium as an impurity produces *p*-type borazon, while a number of substances, including sulphur, silicon, potassium cyanide, and many organic compounds, result in *n*-type borazon.

From *International General Electric*, U.S.A., September, 1961.

● *REFRACTORY-FILLED HIGH-TEMPERATURE ABLATIVE COATINGS*

Expected to be useful for protecting such equipment as rocket-motor cases, nose cones, and aircraft equipment, and in applications where high-temperature corrosion resistance is required, two new ablative coatings have been developed for use over a wide temperature range. The coatings provide protection at low heat levels through a combination of insulation and resistance to thermal decomposition; additional protection is achieved at higher heat fluxes by ablative action. Both types of coating contain heat-resistant phenyl-silane thermosetting resins, but are intended for different temperature ranges, differing in the type of refractory filler used. Thus, one type is recommended for conventional insulation applications up to 3000°F, whereas the second type contains a different type of filler, providing better protection at temperatures above 3000°F.

The method of application of these coatings differs from that of conventional organic coatings in that the base metal must be heated both during and after application. In practice, the part is thoroughly cleaned and is heated to about 220°F; then, while the metal is still hot, a thin prime coat (0·002 to 0·004 in.) is applied by conventional methods. After application, this coat is held at 200°F until it reaches a tack-free, semi-cured condition—usually in from 10 to 15 min. The second and all subsequent coatings can be applied in thicknesses up to 0·010 in. and must be dried at 200°F. After the final desired thickness has been reached, the temperature is gradually raised (about 10°F/hr) to 350°F, and the part is cured at this temperature for 1 hr. After curing, the coating can be sanded or ground down to the proper thickness and then polished to a smooth aerodynamic finish.

From *Materials in Design Engineering*, U.S.A., July 1961, p. 12.

● *IMPROVED COMPOSITION FOR METALLIZING CERAMIC BODIES*

A widely used composition for metallizing a ceramic body to join it with another ceramic or metallic component and to the metallized product contains powdered manganese and molybdenum. While it is true that this composition produces a good bond, it requires sintering in dangerous and expensive atmospheres at temperatures between 1250 and 1350°C. With the object of producing a material that can be bonded to a ceramic body at lower sintering temperatures and in less dangerous and expensive atmospheres, a new metallizing composition has been developed. Furthermore, it is stated that the bond between the ceramic and the metallizing composition has greater strength than that produced by the molybdenum-

Now then, Mr. Jones, how long this time?

Pushed for time, pushed for space, pushed about generally, poor Mr. Jones. But he doesn't do too badly; new sports car, expensive camera, stereo at home . . . and no doubt most of them, like the parking meter, making good use of pressure die castings. Pressure die castings are inseparable from modern living and Wolverhampton Die Casting offer manufacturers high quality components at remarkably low cost in a variety of pleasing finishes. And the massive scale of production they can achieve helps everyone to enjoy a higher standard of living. Wolverhampton pressure die castings in zinc and aluminium point to progress in a big way.
Your enquiries would be welcomed.

THE WOLVERHAMPTON DIE CASTING COMPANY LIMITED
GRAISELEY HILL, WOLVERHAMPTON. TELEPHONE: WOLVERHAMPTON 23831

manganese composition and that it is particularly suitable for use on high-refractory ceramic materials, such as those having an alumina content of more than 85%.

The composition comprises from 40 to 70% by weight of molybdenum boride, from 5 to 30% of cuprous oxide, from 5 to 30% of manganese powder, and up to 15% of manganese dioxide. The addition of the cuprous oxide to the molybedenum boride produces a metallizing composition which can be sintered at lower temperatures than have hitherto been practicable. However, such a composition produces a bond of inadequate strength and, for this reason, the manganese powder and manganese oxide are incorporated to improve bond strength and vacuum tightness considerably. Moreover, the hydrogen-nitrogen atmospheres normally used in sintering other metallizing compositions are not required. In fact, a protective atmosphere such as that produced by passing a stream of air through a bed of hot charcoal, or the sort of gas obtained through the exothermal cracking of natural gas, produces satisfactory results.

For metallizing a ceramic containing 96% alumina, a preferred composition consists of 60% molybdenum boride, 15% cuprous oxide, 15% manganese powder, and 10% manganese dioxide. The composition is milled, together with an organic binder (e.g., cellulose nitrate) and a thinner (e.g.. acetone), for 48 hr in a ceramic-lined ball-mill using hard alumina balls. The composition prepared in this way can be applied at room temperature to the area to be metallized by brush-painting, dipping, printing, spraying, etc. The coated ceramic is then sintered at between 1150 and 1285°C in a reducing protective atmosphere of the type already mentioned. After sintering, the metallized area can be plated with nickel, copper, or silver to facilitate subsequent soldering or brazing operations.

From *Brit. Pat. Spec.* 875,054.
The Carborundum Company, Niagara Falls, N.Y., U.S.A.

● *AUTOMATIC COMPUTER-CONTROLLED X-RAY DIFFRACTION TECHNIQUE*

Conventional X-ray diffraction methods of studying crystals, when performed manually, are time-consuming and require painstaking and tedious work in setting up the equipment, positioning the crystal for a reading, and repositioning it for the next reading, It is now reported, however, that, by applying the principles of automation to crystallography, a new X-ray diffraction technique has been developed and is expected to accelerate considerably research into the atomic structure of crystals. Thus, with the new technique, it should be possible to obtain over 17,000 readings per day, and, while these are being taken automatically, a crystallographer will be left free to evaluate collected data. On the other hand, with manual methods, a maximum of about 3000 readings per day is possible, and then probably for only one or two days at a stretch, since the measurements require complete attention on the part of the crystallographer.

Essentially, the new technique involves the use of a high-speed, general-purpose digital computer to generate a control tape which automatically operates a special type of X-ray diffractometer. Information such as crystal-lattice constants, the wavelength of the X-ray beam, and instrumental constants are fed to the computer on punched cards, together with a compiling programme. The computer generates a magnetic tape from which a punched paper tape is made. Fed into the diffractometer, it controls motors which rotate the crystal and receiving counter into position and then causes an X-ray beam of prescribed wavelength to irradiate the crystal for a precise length of time, the intensity of the beam diffracted by the crystal being measured and recorded on punched tape. The crystal is then automatically rotated to the next position and the process is repeated. The punched tape from the diffractometer containing the readings is converted to a magnetic tape and is fed back into the computer, which integrates the intensities, corrects for absorption, rotation, Lorentz and polarization factors, and prints out the corrected data from which the location of the individual atoms can be calculated. With this technique, it is stated that a crystal can be oriented with an accuracy of 0·01 deg., so that it can be used to study almost any non-biological crystal. It could, however, be extended to protein crystals, which require a crystal-positioning accuracy of 0·001 deg.

From *Bell Telephone Laboratories*, New York, U.S.A., August 1961.

● *IMPROVED IMPREGNATED PAPER FOR CONDENSERS*

The critical performance of a condenser is determined by the characteristic behaviour of its power factor as a function of temperature, these characteristic curves usually exhibiting a minimum in the region between 40 and 60°C and then rising more or less steeply with increasing temperature. The critical performance can therefore be improved by reducing the losses in the working temperature range, by displacing the loss minimum into the region of higher temperatures, and especially by reducing the losses with increasing temperatures in the higher-temperature range, e.g., between 60 and 120°C.

Based on these considerations, an improved impregnated paper for dielectrics, especially in condensers, has been developed, with a view to conferring a better power factor in the tempera-

the advantages of
COLD EXTRUSION

A process of controlled working which
converts a cold steel slug into a precision component.

UP TO 95 % MATERIAL USAGE

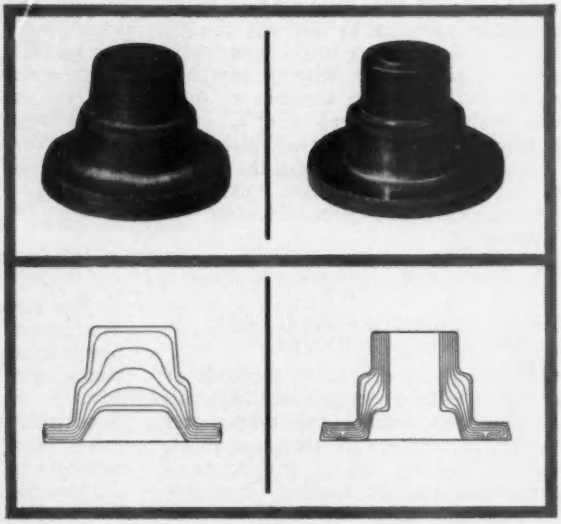
An unusually high proportion of the initial blank is usefully employed and close tolerances can be held. Economic advantage over other methods results from material savings and decreased machining costs.

The heavy cold working imparts the strength of a heat treated steel to low carbon steel whilst the excellent grain flow closely following the finished contour, and the smooth surface finish, show to marked advantage under conditions of fatigue.

Forgings and Presswork Ltd are now equipped to produce a wide range of cold extruded steel parts and would welcome the opportunity to apply their specialized knowledge to *your* products.

The Motor Car Propeller Shaft Flange shown (left), was formerly made from Heat Treated EN8 steel. It is now produced from low carbon steel whose properties after extrusion (right) are equal to those of the EN8.

The pattern of flow lines in the extrusion (right) follows the external contour closely and is superior even to that of a forging where generous machining allowances are usual and really deep piercing is impossible.



Member of the Birfield Group

FORGINGS & PRESSWORK LIMITED

Birch Road, Witton, Birmingham, 6 · Tel: Birmingham East 1262-7 · Grams: Birforge, Birmingham

ture range between 60 and 120°C. In this connection, it is known that normal impregnating media, such as mineral oil or diphenyl chloride, contain impurities which cause dielectric losses. The basic feature of the new paper is therefore the incorporation of suitable finely divided active materials in the paper to act on these impurities, removing them from the impregnant and binding them to the active materials themselves when the previously heat-treated and/or vacuum-treated paper is impregnated. Suitable materials for this purpose include chemically produced metal hydrates and oxides, such as those of silicon, aluminium, or titanium, as well as natural substances, such as aluminium silicates or purified diatomaceous earth. These materials are added to the paper in the form of predominantly colloidal particles averaging 0·5 micron or less in size, with a correspondingly large adsorbing surface area, in quantities ranging from about 0·5% by weight of the paper in the case of titanium hydrate to about 8% in the case of metal oxides such as silicon dioxide, kieselguhr, or calcined kaolinite. The use of these materials produces a qualitative change in the impregnant, causing a reduction in dielectric losses, particularly in the temperature range between 60 and 120°C, even in cases where the impregnant has undergone a special preliminary treatment with adsorbents and/or in a vacuum, prior to its use for impregnation.

From *Brit. Pat. Spec.* 874,981.
Tervakoski Osakeyhtiö, Tervakoski, Finland.

● *IMPROVED METHOD OF CASE-HARDENING METALS*

A well-known case-hardening liquid is methyl alcohol, which decomposes in case-hardening furnaces to form carbon monoxide and hydrogen. Methyl alcohol, however, has the disadvantage that its carbonization action is relatively slight, while high-boiling alipathic alcohols, such as propyl alcohol and butyl alcohol, lead to excessive deposits of carbon on workpieces, preventing further action of the case-hardening gases. Attempts to overcome this disadvantage by adding to ispropyl alcohol sufficient water to vaporize the deposited carbon have not been very successful, as the steam produced tends to convert the hydrocarbons produced on decomposition of the alcohol to carbon monoxide and hydrogen, so that, as with methyl alcohol, only a very slight case-hardening action is obtained.

It is now stated that these disadvantages have been eliminated by the use of a case-hardening mixture consisting of alipathic alcohols with one or two carbon atoms, alcohols with three or more carbon atoms, and at least 5% of pyridine. This mixture produces an excellent case-hardening gas which, at the same time, has a nitriding action on the workpieces treated. There is no limit to the choice of alcohols, provided that they are miscible. When such a mixture is fed into the case-hardening furnace, no deposit of carbon remains on the workpieces, and the case-hardening depth is obtained very quickly and is considerably better than that obtained by conventional methods. Thus, for instance, tests with a mixture of 20 parts by volume of methyl alcohol, 35 parts of ispropoyl alcohol, and 23 parts of pyridine resulted in a total penetration depth of the carbon of 1·7 mm in 5 hr (plus 1 hr of diffusion heating) at 925°C, with a eutectic zone of 0·9 mm and a hardenable zone of 0·4 mm. To achieve especially good hardening, the best results are obtained if there are from 60 to 100 parts by weight of oxygen per 100 parts by weight of carbon in the mixture. If the carbon content exceeds the oxygen content because of the carbon content of the pyridine, small amounts of water, e.g., up to 5%, can be added to the mixture.

From *Brit. Pat. Spec.* 875,998.
Bergwerksverband G.m.b.H., Essen, Germany.

● *VISCO-ELASTOMETER FOR MEASURING FLOW AND ELASTIC RECOVERY*

A new recording visco-elastometer for the measurement of flow and elastic recovery consists essentially of a concentrically arranged fixed precision-bore outer cylinder and a rotatable inner cylinder. The material to be tested is placed in the outer cylinder, which is made of glass, and the concentric inner cylinder is partially immersed in the sample. The inner cylinder is attached to a shaft, to which torque is applied by means of weights suspended from lateral pulleys, these weights being so arranged as to apply a pure torque to the shaft. The angular velocity of the shaft is proportional to the applied torque minus a constant friction torque. The amount of shaft rotation, both during the application of torque and elastic recovery, is determined by a photoelectric recording device, in which an incident light beam is reflected from a ring of 90 mirrors, each subtending an angle of 4 deg., fastened to the outside of the rotor shaft, the reflected rays being detected by a light-sensitive cell which controls the pen position on a strip-chart recorder. The temperature of the sample is controlled by a constant-temperature bath around the outer cylinder, and thermal equilibrium is checked by thermocouples located inside the bath and the rotor. Runs have been made over a range between −40 and +160°C, with temperatures held to within 0·02°C.

The application of torque initiates the determination of viscosity, measurements of which can be made in the range between 10^6 and

Photo by courtesy of Fibres Division, Imperial Chemical Industries Ltd. Manufacturers of 'Terylene' polyester fibre.

C IS FOR CONVEYOR BELTS at a new I.C.I. plant in Cheshire, where eight Goodyear belts of rubber and 'Terylene' carry coke, burnt lime and coke/lime mixture. 'Terylene' was chosen for its flexibility and strength, which allows exceptionally deep troughing so that deck plates, skirt boards, etc., are eliminated and idlers can be spaced 50% wider apart. 'Terylene' also withstands the heat of the coke (carried at up to 120°C), is rotproof and resists moisture penetration. For the *right* conveyor belt, installed in the *right* way and maintained in the *right* manner, contact Goodyear Industrial Products Division at Wolverhampton.

GOODYEAR **THE GREATEST NAME IN RUBBER**

The Goodyear Tyre & Rubber Co. (G.B.) Ltd., Industrial Products Dept., Wolverhampton. Export Enquiries: 17 Stratton Street, London W.1

10^{12} poises. When the rate of rotation becomes constant, as indicated by the chart, the torque is removed, and a record of elastic recovery is produced on the same chart. The range of shear stress is from 10^3 to 10^6 dynes/cm^2, and the practicable range of measurement of elastic compliance is from 10^{-4} to 10^{-7} cm^2/dyne. Determinations of viscosity and of elastic recovery may require from 1 sec to 24 hr. The equipment has been used to measure the linear visco-elastic behaviour of such polymers as polyisobutylene and polystyrene; it can also be used for measuring the visco-elastic properties of materials like asphalt, roofing tar, and (with suitable modifications) vulcanized rubber.

From *NBS Technical News Bulletin*, U.S A., May 1961, pp. 78-79.

● ***TWO-STAGE METHOD OF CLADDING TITANIUM TO STEEL***

Various methods of cladding titanium or titanium alloys to unalloyed or alloyed steels have been proposed. In some of these, an intermediate layer, mainly of nickel, is used between the base material and coating, but the resulting bonding strength between the titanium and the steel is not high enough to satisfy the highest standards required. The use of a silver-manganese solder for cladding titanium to steel has also been proposed, but the results obtained have not been generally satisfactory, owing to the production of brittle transition zones.

To overcome the disadvantages of conventional methods, a new two-stage method of cladding titanium to steel has been developed. In the first stage, a layer of a nickel-copper alloy, preferably containing about 67% nickel and 33% copper, is clad to the steel. In the second stage, the titanium or titanium alloy is clad to the nickel-copper layer, using an intermediate layer of silver or of a silver-manganese alloy containing about 85% silver and 15% manganese. Because the cladding operation is divided into two stages, it is possible to carry out these operations at different temperatures and hence to achieve a satisfactory bonding strength of the materials concerned. In practice, the titanium should be heated together with the other cladding materials in a pack to a temperature somewhat below the melting point of the silver or silver-manganese alloy. This operation should be conducted in an atmosphere of high-purity inert gas, e.g., argon. The cladding surfaces must be metal-bright, this being achieved, for example, by sand-blasting or grinding. After heating in this way, the pack is subjected to rolling operations. To ensure a good bonding strength between the titanium and the silver or silver-manganese layer, rolling must be carried out with a high degree of deformation; in other words, the ratio of the thickness of titanium before and after cladding should be at least 10 : 1.

From *Brit. Pat. Spec.* 876,895. Phoenix-Rheinrohr A.G., Dusseldorf, Germany.

● ***COMBINED CHEMICAL AND ELECTRICAL HIGH-TEMPERATURE BURNER***

A new high-temperature burner boosts the energy from the normal combustion of a mixture of fuel and oxidant by superimposing electrical energy from a low-current, high-voltage a.c. discharge on the flame. By combining chemical and electrical energy in this way, the burner can supply heat in the range between 3000 and 6000°F for chemical and metallurgical processes. An addition of electrical power equal to half that of the chemical combustion power at an optimum air/fuel ratio increases the specific enthalpy of the gas from 1100 to 1600 BTU/lb. Enthalpies of 1900 BTU/lb have been obtained with fuel-rich flames, and higher values are expected with increased electrical power, discharge potentials being at present limited to 2000 V, with currents up to 12 A. Any commercially available fuel, such as natural gas, fuel oil, pulverized coal, or hydrogen, can be used, while suitable oxidizers range from air or oxygen to fluorine. By varying the fuel-oxidizer feed rates, the burner is expected to give a reducing, neutral, or oxidizing atmosphere, as required.

As a potential heat source for either rapid, high-temperature heating or for intense localized heating above 3000°F the burner is likely to be especially useful for heating organic materials, as slower heating methods tend to destroy the molecules and form carbon and various oxides. Other possible uses are in fluid-bed processes, submerged-combustion techniques, the reduction of metal oxides, and glass melting. It should be appreciated that there is a difference between the electrical energy used in the boosted burner and that used in electric-arc techniques. Thus, the high-current, low-voltage system of the arc produces a very high temperature in a narrow column of the arc, whereas the low currents and high voltages of the new burner result in a discharge that is uniformly distributed throughout a much larger volume of the flame.

From *Mechanical Engineering*, U.S.A., August 1961, p. 63.

Readers desiring further information on any developments reported in THE BLUE PAGES are invited to write to the Editor. Copies of the full specifications of any British patents mentioned, which are published by courtesy of H.M. Stationery Office, should be obtained from the Patent Office, 25 Southampton Buildings, Chancery Lane, London, W.C.2. Price 3s. 6d. each.

MS FLUID FACTS

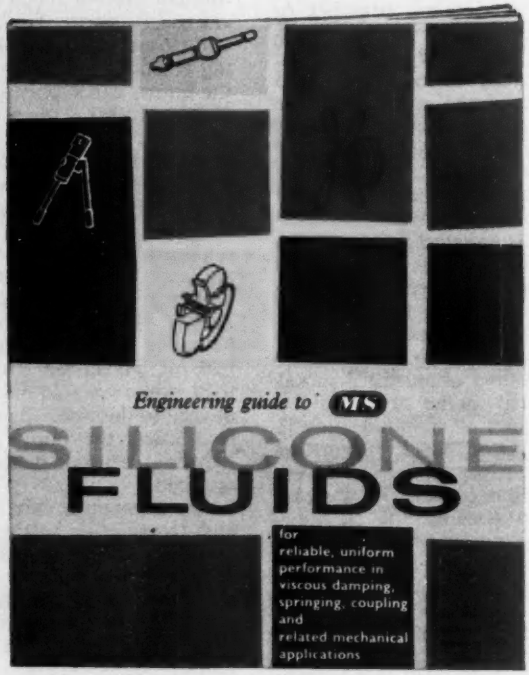
How much do you know about SILICONE FLUIDS

Did you realise that they have:

- *Exceptional thermal stability*
- *Excellent viscosity temperature characteristics*
- *Extreme resistance to oxidation and shear breakdown*
- *Low volatility*
- *High flash points*

No? Well why not find out more about these versatile fluids and the way that they are already being used by industry. Our publication 'Engineering Guide to M S Silicone Fluids' (G11) sets out numerous application examples and gives further particulars of the properties—why not write for a copy today—now!

If your requirement is more for silicone lubricants and greases then 'Silicone Lubricating Fluids & Greases' (G14) *is the publication for you.*



Fred can show you many examples of the applications of MS silicones on **Stand C.4.** *at the Engineering Materials and Design Exhibition.*

Please send me a copy of your illustrated booklet:

'Engineering Guide to MS Silicone Fluids' ☐

'Silicone Lubricating Fluids & Greases' ☐

Name_____

Company_____

Address_____

_____

M.S.F.8a

MS

MIDLAND SILICONES LTD

(Associated with Albright & Wilson Ltd and Dow Corning Corporation)

***first** in British Silicones*

88 Knightsbridge · London · SW1 · Tel: Knightsbridge 7801

Area Sales offices: Birmingham, Glasgow, Leeds, London, Manchester · *Agents in many countries*

THE ENGINEERS' DIGEST
A World Review of DESIGN & PRODUCTION — RESEARCH & DEVELOPMENT
VOL. XXII No. 10 OCTOBER, 1961

The "Unified Transfer System" of Language Translation by Electronic Computers

MECHANICAL methods of translating one language into another have been receiving increased attention, and the merits of various systems have been given considerable publicity. One of the latest is that devised by Machine Translation, Inc., of Washington, D.C., an organization founded to "develop and perfect a system to translate languages by electronic data-processing equipment and to engage in such translations for the benefit of the world's scientific and intellectual communities". As such, it comprises a staff of scientists, notably mathematicians, physicists, and electronics experts, as well as linguists. The president of the company is Mrs. Adriadne Lukjanow, who developed this particular system and who is herself a distinguished mathematician and physicist.

The new system, which was recently demonstrated at the IBM Data Centre in London, in conjunction with an IBM 7090 computer, employs a special method of transferring one set of data into another and has the advantage that no special-purpose computers are required, as it operates on standard general-purpose computers. The process, designated the Unified Transfer System, is suitable for translation of any language into another, provided that one language is an Indo-European tongue. As applied to languages, the system is a fourfold transfer process, involving transfer of the function of words, transfer of the form of words, transfer of the meaning of words, and transfer of the distribution of words. In the Unified Transfer System, these four transfers are considered as a single transfer process and, in order to achieve this transfer, a classification system has been devised for each of the transfers, expressed in the form of a code, these codes being merged into unified code patterns.

In essence, the fourfold transfer process of translation is transformed into the one unified transfer process by establishing the relationship between the constituents of each transfer, expressed in an 8-digit code. The individual codes are incorporated into 479 master-code patterns, each code pattern determining all possible conditions of meaning, form, function, and environment for a class of words. Consequently, each word in the dictionary carries a pattern reference number, so that dictionary operations are greatly reduced. These master-code patterns are stored as part of the programme. The operations in the algorithm are performed on the basis of relationships between the patterns, rather than identification of the individual constituents of either pattern. Maximum utilization of the computer is obtained by octal notation in codes, and by the use of indirect addressing, buffering systems, simultaneous input-output, increased storage capacity, and conversion instructions.

Insofar as the test model demonstrated is concerned, the Russian text to be translated into English is first punched onto IBM cards, and the information on the cards is then transferred to magnetic tape. Simultaneously, a selection from a Russian-English dictionary and the programme codes are fed into the computer by means of magnetic tapes. The computer then performs the function of translation, feeding it to a printer for print-out as a final English translation, which can be edited and retyped for ease of reading. At present, the test model translates Russian into English at the rate of 60,000 words per hour on the IBM 7090 equipment, but it is stated that the full production system, which will be ready within a year, will enable the speed of translation to be increased to over 150,000 words per hour with the same computer. With the new IBM "Stretch" computer, it is predicted that the system may be able to translate as many as 1,000,000 words per hour. In this connection, it should be noted that, because of the extremely high cost of computers and of computer service time, a minimum of 150,000 words per hour is considered essential, if the system is to be economically practicable. It should also be appreciated that there is a drastic shortage of skilled professional Russian-English translators in the U.K. and in the U.S.A., and that most of those at present available are at least 60 years of age, as their presence in these countries mainly stems from emigration following the Russian revolution in 1917. The average skilled professional can, incidentally, translate at the rate of about 400 words per hour.

For the purpose of translation from Russian into English, Machine Translation, Inc. have prepared a general-purpose Russian-English dictionary for machine translation. This dictionary includes over 5000 Russian words and their 32,000 possible English meanings, but a comprehensive dictionary of 50,000 Russian words and over 300,000 English meanings will be prepared during the coming year. This dictionary should permit translation of any non-technical texts (excluding poetry and works of literary merit). For the translation of scientific and technical texts, special dictionaries must be constructed to complement the general-purpose dictionary, and the order in which these dictionaries will be prepared will be dictated by the needs of the scientific community.

It is interesting to note that, because of its rich vocabulary, there is an average of about six different English words, each with its precise shade of meaning, for every Russian word. The computer is programmed to select the more apposite word in relation to the context. If there is any doubt as to the correct word, or if a particular Russian word or its English equivalent is not included in the dictionary, the system is arranged to

print out in brackets the Russian word concerned. In addition, the system takes care of some at least of the linguistic rules of English, in terms of sequence of words, etc. The present test model incorporates only 50% of these rules—sufficient it is claimed, to provide a highly acceptable translation. However, with further simplification of the code and the availability of more free channels for the purpose, it is stated that the remaining linguistic rules will be incorporated into the final production system and that the resulting print-out translation should be of very high quality, not only with regard to accuracy, but also with regard to syntax.

So much for the principles of the system and what is claimed for it. Now, let us consider it purely on the basis of the test model, as demonstrated at the IBM Data Centre. For the purpose of this demonstration, part of an article from the Russian newspaper "Pravda" was translated into English. That the Unified Transfer System has certain inherent advantages is no doubt true, and it can be assumed that the production model, with its full incorporation of linguistic rules, will produce translations in good English. The fact is, however, that, despite the claims made that, even with the test system, a "highly acceptable translation" is obtained, it must be stated with the best will in the world that the resulting translation was in garbled English. The best that can be said for it was that, in the main, it was at least intelligible, and in one or two instances almost faultless. For instance, no one can quarrel with the statement that "*outwardly this document is devoted to the question concerning the reunification of Germany*". But what of this extract?

> "THIS STATEMENT PURSUES OTHER GOALS. MAIN MEANING OF IT, IT IS EVIDENT, COMES TO THE FACT, THAT IN ORDER TO, HAVING CONNECTED QUESTIONS OF DISARMAMENT WITH THE GERMAN QUESTION, TO WRECK TAKING PLACE AT PRESENT TIME THE NEGOTIATIONS CONCERNING THE DISARMAMENT AND TO CONTINUE COLD WAR. THE STATEMENT OF THE WESTERN POWERS WAS BASED ON THE FALSE THESIS, AS IF GERMAN QUESTION IS MAIN CAUSE OF THE PRESENT INTERNATIONAL TENSION, WHEREAS IN FACT OF THE CAUSE OF THIS TENSION SHOULD BE TO SEEK IN THE POLICY OF THE COLD WAR AND THE FRENZIED RACE IN THE ARMAMENT, STUBBORNLY BEING CARRIED OUT BY WESTERN POWERS IN COURSE OF MANY YEARS, IN POLICY OF THE UNITED STATES IN CREATING OF THE ATOMIC BASES ON THE FOREIGN TERRITORIES."

Or this?

> "IN THE STATEMENT CATEGORICALLY ASSERTED, THAT PRECONDITION OF THE AGREEMENT CONCERNING THE DISARMAMENT IS ADVANCE RESOLUTION OF THE QUESTION CONCERNING THE REUNIFICATION OF GERMANY."

Examples such as these only become clear after perusal of an edited (one might almost say "retranslated") English version, thoughtfully supplied with the print-out version. In some cases, it is hard to see how the exact meaning would become apparent unless the services of a skilled Russian-English translator were employed to compare the print-out translation with the original Russian. Certainly, it would be a difficult and tedious (though not necessarily impossible) task to decipher the precise meaning intended directly from the English of the print-out translation.

The demonstration itself was, to say the least, spectacular:—A battery of magnetic-tape spools revolved silently forwards and backwards in their glass-fronted cabinets, lights flickered and flashed here and there, hidden mechanisms clicked and whirred, and dominating all was the sporadic rumble and clatter of the print-out machine. Yet somehow, despite the knowledge that an electronic computer is a complex and highly ingenious creation, we were given the impression that we were watching Hollywood's idea of a scientist at work in a laboratory. True, we were spared the usual bubbling retorts, the hissing coloured vapours, and the high-voltage discharges, but there was a theatrical and unconvincing quality about it all, probably because the end-product was, as we have already said, so imperfect.

There is another point that must be considered:—The information from the original "Pravda" article was based on the use of punched cards. For the benefit of the uninitiated, this means that every single word of the original must be copied and transcribed exactly by means of a special typewriter. To type, say, 8000 words is no mean task, but for an operator with no experience of Russian to type from a keyboard with Cyrillic characters requires considerable practice and takes an appreciable time, possibly something like four or five hours for 8000 words. In any case, to say that the test system can translate at a rate of 60,000 words per hour is highly misleading. It would, in fact, be just as accurate to say that five men can produce a daily newspaper from start to finish in a few hours, based on the fact that the printing presses can turn out copies at this speed, but conveniently forgetting the enormous amount of preparation required to get the contents ready for printing.

Nevertheless, one must be fair:—When this point was brought to the attention of the company representatives, they stressed (quite rightly) that the demonstration was concerned with the test model only, and that, for this particular demonstration, it was found convenient to use punched cards. Other, more rapid methods are available, and, as they pointed out, the eventual use of optical scanning techniques for reproducing and coding printed matter is always a possibility. This, of course, is quite true, as considerable research is being devoted to such techniques and, indeed, notable advances have been made, especially in England. Should scanning methods be perfected, there is no doubt that transcribing the original text to a form suitable for direct recording on tape would be a simple and extremely rapid operation.

Machine Translation, Inc. believe that, within one year, they will be in a position to translate, print, and distribute "Pravda" and other Russian newspapers on the same day they are published in Russia, and furthermore that the translation will not only be strictly accurate, but also in very good English. On the basis of the recent demonstration, at any rate, this seems a somewhat optimistic belief. All the same, Mrs. Lukjanow and her colleagues are obviously dedicated workers, and it is impossible to doubt either their sincerity or their technical ability. They radiate (and, indeed, inspire) confidence, and it may well be that, in the near future, they will be able to do precisely what they claim. Certainly, any subsequent demonstration they may give will be awaited with intense interest. Even the present demonstration shows that they have already achieved something, though it is unfortunately another example of the optimistic American tendency to over-publicize a preliminary project in anticipation of the final product. What a pity it is, then, that this demonstration was not postponed until further progress has been made and more convincing results have been obtained.

The Theory of Combined Steam- and Gas-Turbine Installations

Steam and gas turbines can be combined to produce power more efficiently than can steam-turbine or gas-turbine installations alone. The following article gives a comprehensive survey of the various combinations worth considering and derives the basic thermodynamic relationships which determine their mode of operation.

By C. SEIPPEL and R. BEREUTER

From *Brown Boveri Review*, Switzerland,
Vol. 47, No. 12, December 1960,
pp. 783–799, 8 illustrations.

A NUMBER of possible layouts of combined steam- and gas-turbine installations is shown diagrammatically in Fig. 1, in which diagram A represents a conventional steam plant. In diagrams B, C, and D, the boiler is preceded by a gas-turbine set, the exhaust heat of which is utilized in the boiler furnace. In diagrams B and C, air is compressed in a compressor *l* and heated in a special combustion and swirl chamber *m* to the desired input temperature of the expansion turbine. The air can be heated in an air heater before it flows into the combustion chamber. In the turbine *n*, which drives the compressor, the hot gas gives up power, as well as supplying an appreciable useful output. The gas then enters the boiler furnace and still contains an ample amount of oxygen for combustion. During compression, the air is heated by more than 100°C, so that it is not capable of reducing, in the air heater, the temperature of the exhaust gases to the extent possible in scheme A. Since it is necessary, however, to cool the exhaust gases to the limit imposed by dew point and corrosion, diagram B incorporates an independent steam circuit *o* in which the waste heat can be utilized. As an alternative, diagram C shows the waste heat being transferred to a leg of the feedwater system, which in many cases renders the air heater superfluous.

In diagram D, the air is not raised to the temperature required by the expansion turbine by internal combustion, but is heated externally in the boiler. However, this necessitates a costly heat exchanger; on the other hand, the expansion turbine operates with clean air. This, so far, is the only possible solution for combined installations in which the fuel has a high ash content.

Diagram E shows a pressure-fired boiler, for instance of the well-known "Velox" type. The main part of the boiler precedes the gas turbine and operates under pressure. The other part, usually only the economizer, follows the gas turbine.

In diagram F, the gases are expanded in two stages, i.e., a high-pressure stage with high temperatures, and a low-pressure stage with lower temperatures, the object of which is to reduce the temperature of the exhaust gas more than can be done by a heat exchanger. The walls of the latter must be colder than the gases, this being unnecessary in the low-pressure turbine. Finally, it must be mentioned that it is also possible to combine a gas turbine with a waste-heat boiler, as in diagram G.

The systems illustrated in the diagrams permit certain variants. In B, C, E, and F, the air heater can be omitted, but this may affect the efficiency under certain conditions. Moreover, it is permissible to dispense with recuperation in B, provided that a drop in efficiency is acceptable. The air can also be compressed in several stages in conjunction with intercoolers, and the gas can be expanded in several stages with intermediate reheating.

At this point, one problem warrants special attention: combined installations, such as B and C, have two combustion chambers in series. The second operates with air containing a reduced amount of oxygen, but at a high temperature, so that combustion does not present any difficulties. On the other hand, with gas or oil firing, it is possible, in the event of a misfire in one of the combustion chambers, for the flame to flash over explosively from the other. The installation must consequently be built in such a way that this cannot cause any damage.

The Thermodynamics of Combined Steam- and Gas-Turbine Plants

Steam Plant with a Gas-Turbine in the Combustion Circuit

Starting with a steam plant as in diagram A, the first question to be investigated is in what circumstances and by how much can the efficiency be improved by inserting a gas turbine in the combustion circuit, as shown in scheme B.

Energy Balance:—

The temperature-enthalpy diagram for the combustion air (*A*) and for the combustion gases (*G*), referred to the enthalpy at ambient temperature, is given in Fig. 2. Also plotted in this graph are the successive stages in the combustion circuit (0–4). The enthalpy flow referred to 1 kg of air per second is indicated in the right-hand column of the table subjoining this illustration.

Since temperature-enthalpy diagrams of the type shown in Fig. 2 can become rather complicated, a different method of representation has been adopted in the following. Thus, Fig. 3 corresponds to Fig. 2 unfolded, so that changes in energy in the combustion circuit can be placed successively, regardless of their sign. The changes can now be observed from the drop or rise of the temperature curve, and from an additional diagram below the main diagram. It should be noted that, in contrast with Fig. 2, Fig. 3 is not drawn to scale. Fig. 4 shows the successive stages in the combustion circuit corresponding to scheme B in Fig. 1.

The heat balances for schemes A and B can now be established from Figs. 3 and 4. The heat absorbed by the steam for scheme A can thus be written as

$$V_o = \tau_{iH} H_o - Z_o \quad \ldots \quad (1)$$

and the power output is

$$P_o = \tau_{ith} V_o - P_{o,\,aux} \quad \ldots \quad (2)$$

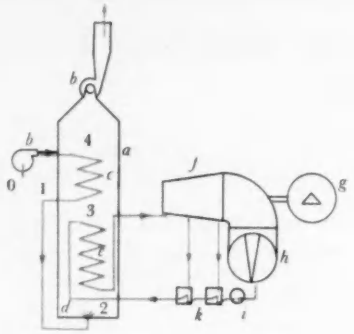
For scheme B, the heat absorbed by the steam is

$$V = \tau_{iH} (H_1 + H_2) - Z - (E - C) - R \quad \ldots \quad (3)$$

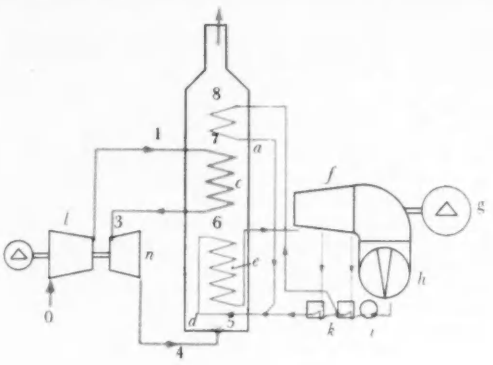
and the power output is

$$P = \tau_{iel} (E - C) + \tau_{ith} V + \tau_{iR} R - P_{aux} \quad \ldots \quad (4)$$

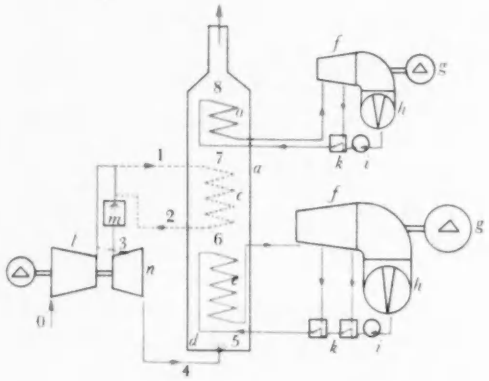
In these equations, τ_{ith} is the thermal efficiency of the steam turbine, referred to the terminal output, less the



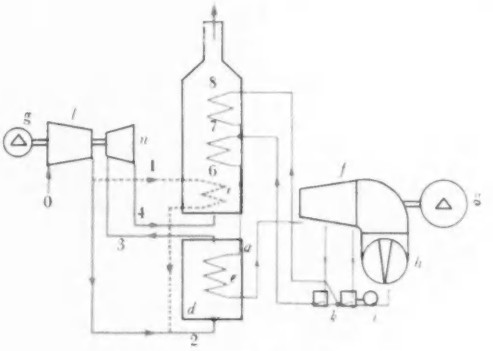
A



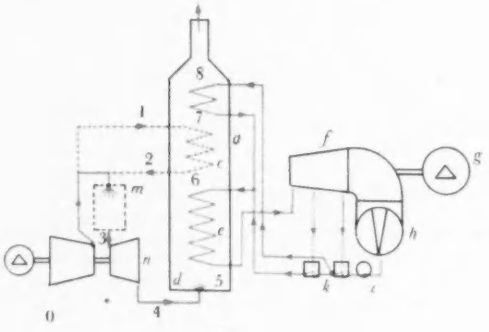
D



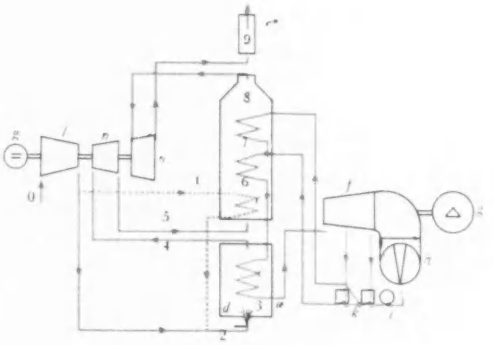
B



E



C



F

power consumed by the drives of the feedwater and cooling-water pumps, and the heat V_o absorbed by the steam; P_{aux} is the net amount of power consumed by the auxiliaries, excepting the feedwater and cooling-water pumps; η_{el} is the efficiency of the generator of the gas-turbine set; and η_R is the thermal efficiency of the utilization of the waste heat (recuperation efficiency).

In all cases, the suffix $_0$ refers to the steam plant.

The two schemes can now be compared on the basis of an air throughput of 1 kg/sec and assuming the following conditions:—

(i) The pressure and temperature of the live steam —and, if necessary, of the reheated steam—as well as the vacuum and feedwater temperatures

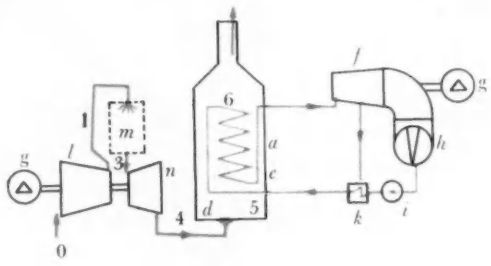


Fig. 1. Circuit diagrams of steam- and gas-turbine installations, the orange lines referring to open combustion circuits and the green lines to closed water-steam circuits.

a = Boiler
b = Boiler fans
c = Air heater
d = Combustion chamber with burner
e = Steam part of boiler
f = Steam turbine
g = Generator
h = Condenser
i = Feedwater pump
k = Feedwater heater and de-aerator
l = Compressor
m = Combustion and swirl chamber
n = Gas turbine
o = Independent heat-recovery steam circuit

are equal in both cases. The internal efficiency of the steam turbine, the feedwater and cooling-water pumps, and the quality of the feedheaters and generators, and hence the thermal efficiency of the steam turbine are also equal in both cases. This most important assumption naturally applies only to the high-pressure steam circuit in B, but not to any recuperation circuit (top of diagram B), the steam data in which are limited by the gas temperature

(ii) The fuel input is also assumed to be equal and to correspond to the smallest possible amount of excess air.

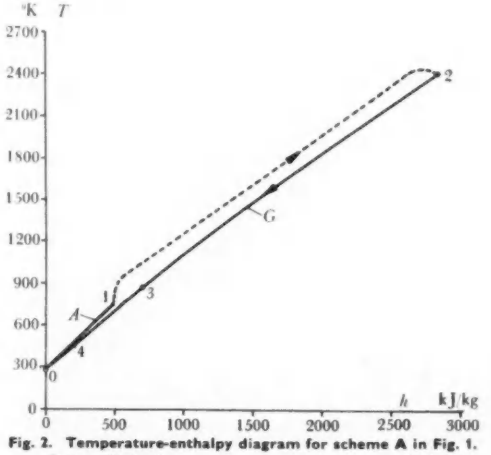


Fig. 2. Temperature-enthalpy diagram for scheme A in Fig. 1.

0–1	Air heating	Q_0 (+)
1–2	Combustion	
	Introduced as fuel which calorific value H_0	
	Remaining after subtraction of losses due to radiation and unburnt fuel	$\tau_{iB}H_0$ (+)
2–3	Heat given up to steam circuit	V_0 (−)
3–4	Heat given up to air heater	Q_0 (−)
4–0	Heat lost up the chimney	Z_0 (+)

(iii) The exhaust-gas temperature, and hence the exhaust-gas loss, are assumed to be equal in both cases.

(iv) The power for the auxiliary pumps of the steam turbine, especially the feedwater and cooling-water pumps, is taken into account in τ_{ith} and is thus proportional to the output of the steam turbine. The remaining auxiliary power is chiefly consumed by the boiler fans in A, which are omitted in B. Instead, the gas-turbine operates with a back pressure, in order to overcome the boiler resistance, thereby reducing the gas-turbine output. In the calculation, these two approximately equal terms can be omitted, so that the auxiliary power can be expressed as $P_{aux} = P_{0,\,aux}$.

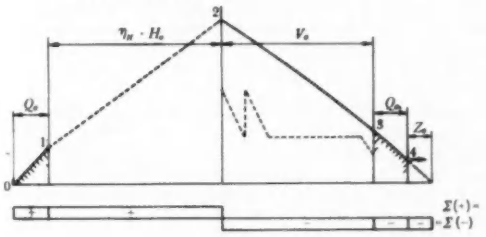


Fig. 3. Unfolded temperature-enthalpy diagram for scheme A in Fig. 1.

The dotted line below V_0 refers to the steam state in the boiler.

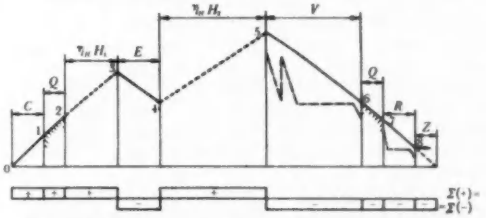


Fig. 4. Unfolded temperature-enthalpy diagram for air and combustion gas according to scheme B in Fig. 1.

The dotted line below V refers to the high-pressure steam states in the boiler, and the dotted line under R to the low-pressure steam states in the heat-recovery circuit.

0–1	Compression	C (+)
1–2	Air heating	Q (+)
2–3	First combustion stage	$\tau_{iH}H_1$ (+)
3–4	Expansion	E (−)
4–5	Second combustion stage	$\tau_{iH}H_0$ (+)
5–6	Heat given up to steam circuit	V (−)
6–7	Heat transferred to air	Q (−)
7–8	Heat-recovery stage (recuperation)	R (−)
8–0	Heat lost up the chimney	Z (−)

Under these assumptions, the equation for the flow of energy for scheme B can be rewritten as

$$V = V_0 - (E - C) - R \quad .. \quad .. \quad .. \quad (3a)$$

and the power equation as

$$P = \tau_{iel}(E - C) + \tau_{ith}[V_0 - (E - C) - R] + \\ + \tau_{iR}R - P_{aux} \quad .. \quad .. \quad (4a)$$

If eq. (2) is subtracted from eq. (4a), the gain in output per kg/sec of air becomes

$$P - P_0 = (\tau_{iel} - \tau_{ith})(E - C) - (\tau_{ith} - \tau_{iR})R \quad (5)$$

Since equal heat input is assumed, the percentage improvement in the thermal efficiency of the installation, referred to that of the steam plant, is

$$\frac{\triangle \tau_i}{\tau_{i0}} = \frac{P - P_0}{P_0} = (\tau_{iel} - \tau_{ith}) \frac{E - C}{P_0} - (\tau_{ith} - \tau_{iR}) \frac{R}{P_0} \quad (6)$$

The expression (5) consists of a first, positive, additive term corresponding to the output of the gas-turbine set $\tau_{iel}(E - C)$ from which $\tau_{ith}(E - C)$ must be subtracted, because the amount of heat $(E - C)$ is obtained from the gas, and is thus not available for the steam cycle. It contains a second, negative term, i.e., $-(\tau_{ith} - \tau_{iR})\ R$, originating from the residual heat R which performs work with a poorer recuperation efficiency τ_{iR} than if it had been utilized in the high-pressure steam circuit with τ_{ith} via the air heater.

With the aid of eq. (6), it is possible to calculate the improvement effected by combining a gas turbine with a steam plant. It is now necessary to study more closely the recuperation power R and the efficiency of recuperation τ_{iR}, and to find the optimum values for compression C and expansion E.

Recuperation Power:—

In the straightforward steam plant, the exhaust gases at the air inlet to the preheater are considerably hotter than the incoming air. The enthalpy of the exhaust gases, referred to the ambient temperature (Fig. 5a), is higher by the amount of the exhaust-gas losses Z_0. In the combined installation, the air is already heated to a temperature T_1 by compression before it enters the heater. It is often warmer than the exhaust gas leaving the steam plant. Consequently, the gas temperature at the outlet from the air heater has to be increased, in order that the heat may be transferred with a sufficient temperature gradient. An obvious solution is to dispense with the part of the heater in which the air is heated to T_1 in the ordinary steam plant, and to retain the rest of the heater unchanged. The air is then heated with the same temperature difference between gas and air, and attains the same final temperature as before (Fig. 5b). In this case, the loss of the transferred amount of heat corresponds exactly to the work of compression. This heat is supplied by the recuperator and is given by $R = C$.

Frequently, however, there are reasons for deviating from this law, and these are outlined in the following:

(a) In the steam plant, a reduction in the temperature gradient between air and gas is defined by the atmospheric temperature and by the lowest temperature to which the exhaust gases can be cooled without moisture condensing and giving rise to difficulties such as corrosion. In the combined plant, the temperature difference may be lowered, as long as this is advantageous for the efficiency, which should be rated higher than the extra costs for the heat exchanger. The enthalpy difference per second between gas and air is then, as can be seen from Fig. 5c, no longer Z_0 but $\triangle$, which is smaller than Z_0. In this case, the recuperation power is

$$R = C - (Z - \triangle) \quad .. \quad .. \quad .. \quad (7)$$

(b) In the ordinary steam plant, the temperature difference in the air heater can be reduced by preheating the air by low-pressure bled steam before it is conveyed to the flue-gas heat exchanger. The thermal efficiency can thus be improved.

(c) Sometimes, the recuperation power is increased above the value C, in order to dispense completely with the air heater (1–2 in diagram B).

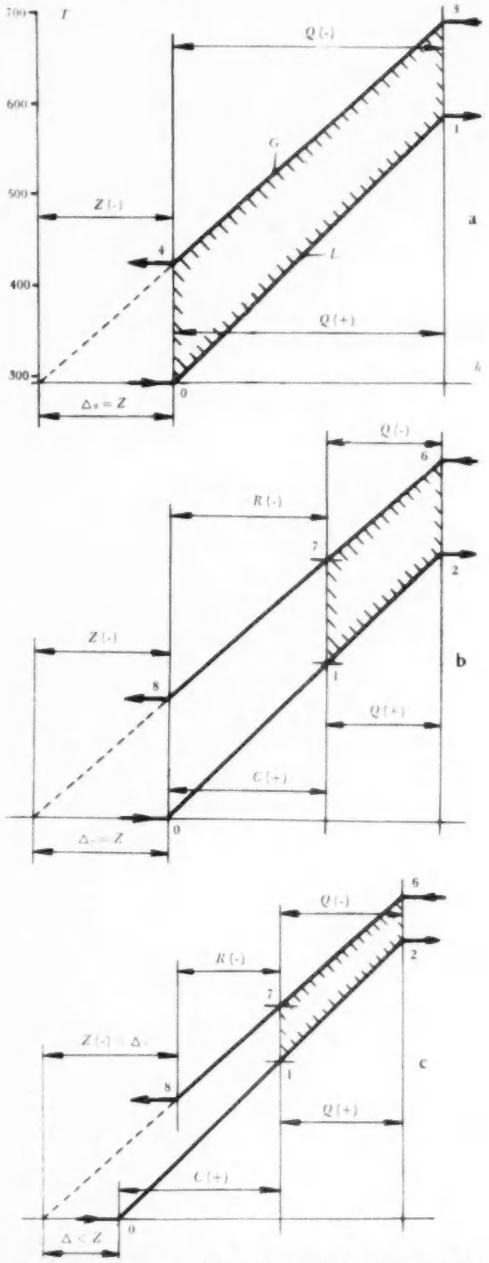


Fig. 5. Temperature-enthalpy diagram for the air heater (a) according to scheme A with $R = 0$, (b) according to scheme B with $R = C$, and (c) according to scheme B with $R = C - (Z - \triangle)$.

(d) Instead of utilizing the heat in a waste-heat boiler with a special turbine, as in B, it can be used to heat the feedwater for the main turbine, as in C. It is then advantageous for the feedwater flow to be divided after it passes the lower feed-heating

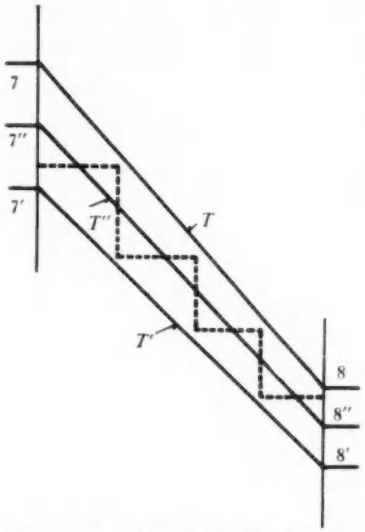


Fig. 6. Temperature-enthalpy diagram in the recuperator and bled-steam feedwater heaters, T referring to exhaust-gas, T' to feedwater, and T'' to bled-steam temperatures.

stages. One part flows through the upper feed-heating stages, the rest through the waste-heat boiler. This is feasible since the "hydraulic coefficient" of the current of water—the product of the specific heat and the mass flow—is greater than that of the gas current. In diagram C, which illustrates this variant, the air heater is shown dotted, because in most cases it may well be dispensed with.

Fig. 6 shows the temperatures in the recuperation system. The gas current is cooled from T_7 to T_8, while the portion of the feedwater current is heated from T_8' to T_7'. The slope of the line T_7'-T_8' depends on the ratio in which the feedwater current is divided. It could be made parallel to the gas line T_7-T_8. It is still better to make T' proportional to T; this not only simplifies the calculation, but also gives an optimum thermodynamic result.

When an air heater is provided (diagrams C and D), T_7 is determined, as before, by the compression temperature and the temperature difference in the air heater, and eq. (7) applies. Care must be taken to ensure that the feedwater temperature T_7' agrees with the final temperature of the bled-steam heating or of any intermediate stage; otherwise, the ratio in which the water is divided must be changed, dispensing with the exact proportionality of T and T'.

If the flue-gas is not used to preheat the air, T_7 is determined by the final temperature T_7' of the feedwater and the temperature difference of the heat transfer from flue-gas to feedwater. In this case,

$$R = (h_7 - h_8)\, m_E \qquad (8)$$

in which $h_{7,8}$ are the enthalpies and m_E the mass flow of the flue-gases.

(To be concluded next month)

Flexible Insulated Electrical Conductors for High-Temperature Applications

By A. R. GARDNER

From *Product Engineering*, U.S.A.
Vol. 32, No. 32, August 7, 1961,
pp. 82–85, 4 illustrations

AT temperatures in the 500°F range, it is no problem to find suitable electrical conductors and satisfactory durable materials to insulate them. In fact, a number of flexible insulating materials, using fluorocarbon plastics, silicones, glass, mica, and asbestos, are giving excellent performance in this temperature range, and some are capable of withstanding even higher temperatures for short periods. It is true that some inert materials, such as ceramics and refractories (including porcelains and cold-moulded compositions) are suitable for long-term service at temperatures of 600°F and above, but these materials are generally rigid. Indeed, suitable flexible insulating materials, even for short-term service in the range between 600 and 700°F, are by no means easy to find. For use at temperatures of 800°F and above, the selection is extremely limited, and such materials as do exist pose a large number of problems of their own.

Almost all flexible insulating systems for high-temperature applications involve the use of an inert material, e.g., glass, mica, or asbestos, with a flexible binder. Unfortunately, nearly all available binders tend to evaporate or to degrade after only a few hours at temperatures between 800 and 1000°F, leaving stiff, fragile shells. They may still provide sufficient insulation if there is no flexing and no thermal cycling but, if they are flexed, they may crumble. Similarly, if they are brought back to room temperature, they may stiffen, crack, and deteriorate electrically to the point where they become useless. Furthermore, organic binders may carbonize, so that tracking may become a serious problem.

Other difficulties to be borne in mind include the fact that some non-conductors, such as glass, become electrically conductive at high temperatures, while many coatings tend to migrate into the wires, reducing conductivity. A further complication is that some materials which perform best at elevated temperatures are comparatively unsatisfactory at room temperature, when they pick up moisture or lose their flexibility. Even all-inert braided sleeving may cause trouble. Thus, if the braid angle is less than 50 deg., the sleeving may tighten and buckle, breaking the wires inside.

The conductors must also be specially chosen and protected for high-temperature applications. For this purpose, special wire, coated to prevent oxidation, must generally be used and, in this respect at least, considerable progress is being made. For magnet wire, new fluorocarbon enamels, capable of withstanding extended exposures to temperatures between 500 and 600°F, or short exposure to temperatures of 700°F, are available. In addition, anodized aluminium is giving good service at 930°F. However, the oxide coating is relatively

fragile, so that anodized wire also requires protection.

Ceramic-coated nickel-clad copper appears to be suitable for withstanding temperatures of 1000°F and above, but has a lower electrical conductivity than a standard copper conductor of the same size. On the other hand, nickel-plated copper and silver-plated copper have excellent conductivity ratings, but most conductors of this type are limited to temperatures below 800°F, even when protected by a ceramic coating. New coating systems under investigation include electrophoretic silica and extruded boron nitride. These systems appear promising, but at present are far from sufficiently developed to be suitable for commercial application.

For miniature wire leads, many new combinations are under development and test. Of these, fluorocarbon-enamelled, glass-and-wire-wrapped, nickel-clad copper seems promising for temperatures up to at least 800°F, while fibre-cored, ceramic-coated wire may be able to withstand even higher temperatures for long periods.

For aircraft transformer coils intended for service in the 930°F range, new encapsulation and impregnation techniques are being developed, some systems involving combinations of both techniques. For instance, one manufacturer is testing a system in which the coils are first wound, then encapsulated in a porous ceramic, and finally vacuum-impregnated with molten glass.

The development of suitable connectors and terminals is keeping pace with that of high-temperature wire. Thus, at least three American companies can supply connectors for use in the 1000°F range, and one company can provide a ceramic series for use up to 1250°F. Units for even higher temperatures (up to 1750°F) have been made and tested, but are not as yet in actual production.

It must be appreciated that every wire and coating system has its limitations. For example, most glass wraps are relatively bulky and have little resistance to thermal cycling; in addition, glass reacts with silver wire, causing embrittlement, and, as already stated, becomes electrically conductive at high temperatures. The tendency of bonding agents to evaporate is a serious problem, though it is possible that the use of new bonding compositions, such as phosphate systems and perhaps colloidal alumina, may help to reduce evaporation to a great extent. Such inorganic materials may also help in the development of new high-temperature "enamels" for high-temperature wire, though their tendency to pick up moisture must be carefully watched.

Anodized-aluminium coatings have fair flexibility and heat resistance, but are so thin that voltages are limited. Also, their abrasion resistance is low, and their moisture resistance is by no means outstanding.

Silver wire has good conductivity and offers the advantage that its oxide reduces back to pure silver at high temperatures. Its cost is, however, a problem and so too is silver migration.

The long-term exposure of nickel-clad copper wire may result in diffusion of the nickel into the copper, with a resulting loss of conductivity. For this reason, such combinations as high-purity chromium plate, and anodized tantalum and columbium on copper and silver are under test, though new ceramic coatings will be required to provide adequate protection for such systems.

For wire leads, fibrous felts and cloth offer reasonable flexibility and heat resistance, but the bonding agents used to strengthen them may also cause them to stiffen, to increase moisture pick-up, or to give rise to other undesirable properties.

Even when it is possible to take advantage of rigid, inert materials, certain problems can still arise. For example, ceramic-bonded mica may swell up under heat to a point where insulated cables require 30 or 40% more space after high-temperature exposure than they do initially. As a matter of fact, even where materials do not swell, satisfactory high-temperature performance almost always involves thicker insulation and greater spacing between conductors than are necessary in the range below 500°F. The overall increase in the size of an insulated assembly for this reason may be as much as 50%.

Most experts agree that the best hope lies in the development of improved wire and better ceramic coatings. For instance, it may be possible to develop suitable combination coatings. One manufacturer is currently investigating pigmented polyester resins (metal-modified compositions, heavily loaded lead borate glass frit, and a silica refractory), which seem very promising for applications at temperatures of 600°F and which may possibly be suitable for use up to 930°F. In these materials, the polyester burns out at high temperatures, but the remaining inorganic enamel appears to offer good protection. Another manufacturer is testing electrophoretically deposited alumina and silica coatings and an extruded boron nitride coating bonded with phosphates and fluoro-organic materials.

To find a satisfactory insulating system for use up to 1000°F is likely to be difficult. Conductors for the range of temperature between 600 and 1000°F must not only be heat-resistant, but must also meet the requisite specifications for conductivity, temperature coefficient of resistance, magnetic permeability, thermal stability, tensile strength, elongation, flexibility, specific heat, and availability. Similarly, the insulation must be thermally stable, strong, flexible, readily available, and easy to fabricate. In addition, it must have a specific dielectric strength, dielectric constant, and dissipation factor, as well as good heat-transfer characteristics and resistance to abrasion, moisture, and solvents. To all these factors must be added that of cost. For instance, the least expensive of the high-temperature wire leads currently available cost from two to three times as much as those designed for the conventional temperature range.

For use at temperatures between 600 and 850°F, it is believed that a silicone-impregnated asbestos wrapping, covered with a Teflon tape and overbraided with Teflon-coated and impregnated glass—by no means a simple assembly—is at present the best solution. For temperatures between 850 and 1000°F, the use of a composite insulation has been suggested, consisting of glass-backed mica tape applied helically about the conductor, with an over-binder of inorganic fibrous insulation, e.g., asbestos, and a flexible metal sheath around the entire assembly. For use in the temperature range between 1000 and 2000°F, one manufacturer utilizes a nickel-clad copper conductor, sheathed in a flexible inorganic fibrous insulation and covered with a special ceramic-fibre braid.

With a view to overcoming all these problems, considerable research is being undertaken by a large number of organizations. For this reason, it is felt that a temperature limit of 1000°F is only a temporary barrier and that conductors for higher ranges may soon be available. If such conductors materialize, they will be of importance not only to those designing equipment for very high temperatures, but also for those who require more durable components for longer-term service in a range of more moderate temperatures.

Investigation into the Creep Behaviour of Unalloyed Titanium

By W. KNORR and H. SCHOLL

From *Technische Mitteilungen Krupp*, Germany,
Vol. 19, No. 2, June 1961,
pp. 51-60, 10 illustrations.

DESPITE its relatively high strength, unalloyed titanium has a definite tendency to creep, even at room temperature[1]. Permanent deformations take place, even at loads well below the yield point, and this behaviour has been investigated by Adenstedt[2]. Subsequently, Luster, Wentz, and Kaufmann[3] determined for a titanium of relatively high strength the 1000-hr rupture strength at various temperatures. Their results can be expressed in non-dimensional form by dividing the values for the 1000-hr rupture strength by the ultimate tensile strength at room temperature. It is then found that this ratio is less than unity, even at test temperatures slightly above room temperature, and falls off very rapidly above 400°C, typical values of the ratio being 0·72 at 27°C, 0·45 at 200°C, 0·15 at 430°C, and 0·05 at 540°C.

Kiessel and Sinnot[4] showed that the creep strength of titanium falls off at first when the temperature is raised above room temperature, but increases again at higher temperatures. They found that the stress required for a specified constant creep rate of 10^{-4}% per hour, after an initial decrease, rises again at temperatures above 100°C and reaches a maximum between 200° and 250°C. In this maximum-strength region, the elongation practically coincides with the elongations associated with the 1% proof-stress values at the corresponding temperatures, whereas at temperatures either above or below this region the 1000-hr elongation is considerably below the 0·2% proof-stress value. These results explain the considerable decreases in stress observed with increased testing times at room temperature for the time-rupture curves and the curves of time-elongation, whereas a nearly horizontal trend is found in the region of minimum creep rate. The abnormal shape of the creep curves in this temperature range is related to recrystallization phenomena, as observed by Rosi and Perkins[5] in short-time tests at temperatures around 200°C, and subsequently attributed by Churchman[6] to titanium single crystals and to the presence of foreign elements, especially dissolved oxygen and nitrogen, in the titanium lattice.

In view of the increasing use of titanium, particularly in the chemical industry, more detailed information is needed on its creep characteristics. Furthermore, the effects of variations between different melts, varying percentages of impurities, and different mechanical treatments, should be determined. It is for these reasons that the investigations described in this paper have been carried out by the authors.

Test Procedure

All tests were carried out with forged bars of round sections and with rolled sheet of 3 mm thickness, from four different melts, the compositions of which are given in Table I. Melts *A* and *B*, with an ultimate tensile strength of 56 kg/mm², had different iron, nitrogen, and oxygen contents. The other two melts, *C* and *D*, were experimental melts with low Brinell-hardness values (about 150 kg/mm²), and low ultimate tensile strengths (36 and 35 kg/mm² respectively). From all the melts, forged and annealed specimens (at 650°C in air) were prepared and tested, and for melt *B* different specimens, in addition to only forging and annealing, were subjected to cold-drawing, forging, and annealing, and also to forging, hot-rolling, and annealing.

TABLE I: COMPOSITION [%] OF TITANIUM MELTS INVESTIGATED

Melt	Carbon	Iron	Hydrogen	Nitrogen	Oxygen
A	0·02	0·20	0·002	0·060	0·17
B	0·02	0·03	0·001	0·017	0·34
C	0·02	0·04	0·004	0·010	0·11
D	0·02	0·03	0·001	0·015	0·07

Creep tests were carried out at room temperature, at 150°C, and in some cases at 175°, 200°, 250°, and 300°C, furnace temperature being kept constant to within ±1°C. Bar materials were tested at 24°C with specimens of 5-mm diameter and 40-mm gauge lengtn. At higher temperatures, single-specimen furnaces were employed, using specimens of 8-mm diameter and 55-mm gauge length. From the rolled sheet, flat specimens of 15 mm width were cut, these being welded to the clamping heads.

In all cases, the specimens were tested under constant loading, and elongation was measured continuously, so that, in principle, no unloading or removal of the specimens was required throughout the entire test period. Elongation measurements were made with two dial gauges per specimen, which indicated the relative displacements of the clamping heads at the two ends of the specimen. In the tests above room temperature, quartz rods were used to transmit these displacements to measuring positions at a lower level outside the furnace. The values of elongation determined from these con-

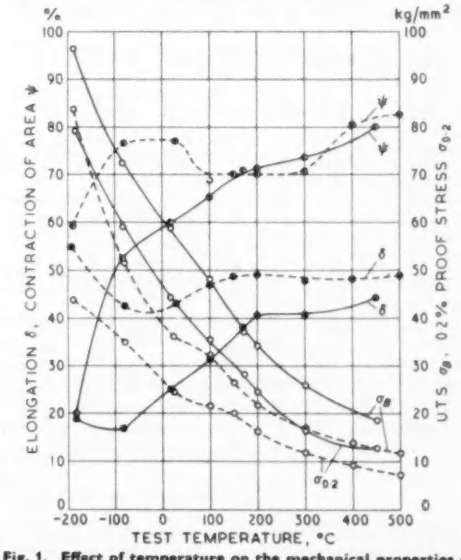


Fig. 1. Effect of temperature on the mechanical properties of melt *A* (solid lines) and of melt *B* (dotted lines).

tinuous measurements agreed, to within $\pm 2\%$, with those obtained from the displacement of the usual pop marks. In cases of doubt, the latter values were used as a basis, and the continuously indicated elongations were corrected accordingly. This procedure was necessary in some cases, particularly with the flat specimens.

Test Results

The mechanical properties of melts *A* and *D*, determined in tensile tests at various temperatures, are given in Fig. 1. The main features are the notable degree of ductility below room temperature and the greater decrease in strength of melt *A* relative to melt *D* in the temperature range below 200°C. Elongation and reduction of area at rupture increase with temperature in the case of melt *A*, whereas for melt *D* (which is considerably more ductile below room temperature) elongation hardly increases at all above 100°C. This phenomenon, and the slower decrease in strength above 100°C, are attributed to the recrystallization processes previously mentioned.

The creep curves for melt *A* at different temperature levels are shown in Figs. 2 and 3. At all temperature levels, the curves first rise fairly steeply and then flatten out. The region of maximum creep rate (greatest slope) is displaced towards the left, i.e., towards shorter loading times, as the load is increased. The maximum creep rate also moves in the same direction if the test temperature rises at constant stress, in the region from 150° to 300°C. After passing through this maximum, the creep rate decreases in all cases, and only after a very long period of testing increases again at high stress levels to the point where rupture of the specimen finally occurs.

The kink or discontinuity shown in some of the curves in Fig. 2 was due to removal and subsequent re-application of load. Corrected curves can be obtained by redrawing the continuation of these curves at a lower level, i.e., by subtracting the height of the discontinuity, for evaluations of rupture limits. This discontinuity is most noticeable at low creep rates (e.g., at 16·25 kg/mm² in Fig. 2). Both the maximum value of creep rate and the additional elongation occurring after load removal

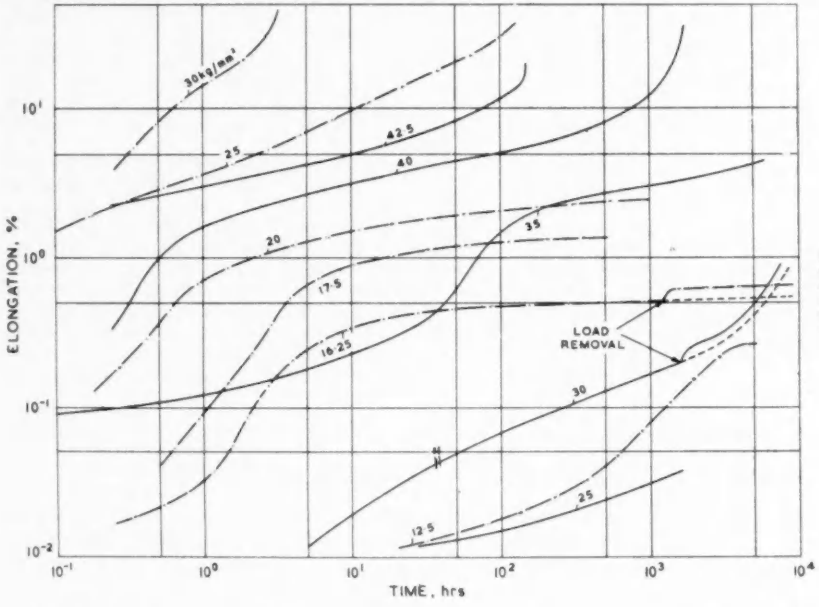


Fig. 2. Elongation of specimens from melt *A* as a function of time at 24°C (solid lines) and at 150°C (chain-dotted lines), under various loads.

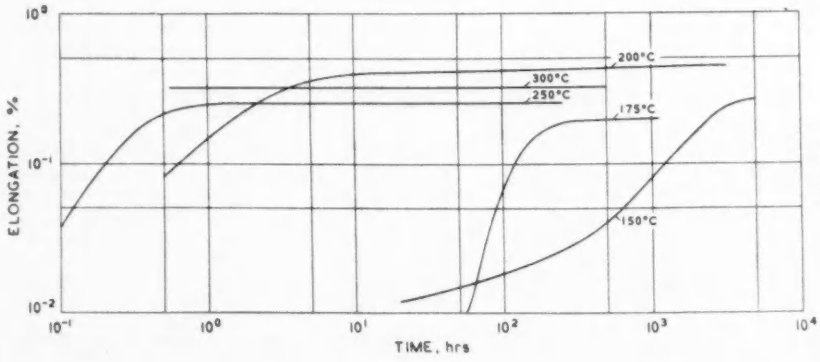


Fig. 3. Elongation of specimens from melt *A* as a function of time at higher temperatures, under a load of 12·5 kg/mm².

at an intermediate stage are attributed to the diffusion of dissolved foreign atoms and their interaction in dislocations[7].

At temperatures around 300°C, the creep curves are radically different from those at lower temperatures. At the 300°C level, there is a high initial elongation, which increases with increasing stress; after a very short time, the creep rate then decreases practically to zero, and remains at this low value for a very long time, even if a very high initial elongation (greater than, say 10%) is obtained. The time-elongation curve is thus substantially horizontal. In no case was there observed a transition into the tertiary creep range in the range of stresses investigated. In this condition, however, a slight increase in applied load was then sufficient to produce rapid rupture of the specimens.

These tests on melt *A* were supplemented by measurements on specimens of melt *B*, which had the same ultimate tensile strength. In melt *B*, the higher strength, as compared with melts *C* and *D*, was due mainly to the increased oxygen content, as other impurities did not make it appreciably different from pure titanium of lower strength. It was considered of interest to find out whether elongation, particularly at higher temperatures, decreased as a result of the greater diffusivity of oxygen, and also to investigate the effects of mechanical treatments on creep strength.

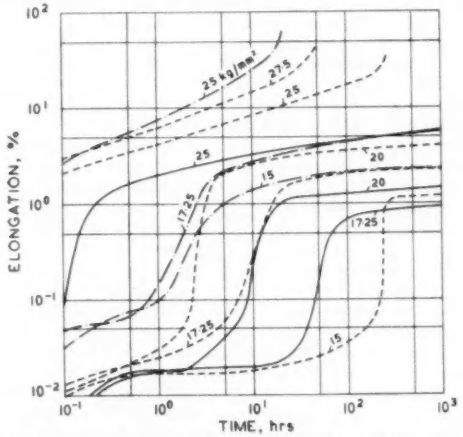


Fig. 4. Elongation of specimens from melt *B* as a function of time at 150°C, under various load.
Solid lines: Forged and annealed.
Dotted lines: Forged, cold-drawn, and annealed.
Chain-dotted lines: Forged, hot-rolled, and annealed (flat specimens).

From earlier tests, it was known that increasing sizes of the polygonal α-grains are associated with a considerable decrease in creep strength at room temperature. The permanent elongation becomes twice as great at constant stress level and during the same test period, when the grain size, as a result of annealing in the α-region, is increased from 500 μ^2 to more than 10,000 μ^2. After annealing in the β-region, which also causes an increased grain size, though the α-phase precipitates and forms an oriented Widmanstätten structure, the creep strength is again considerably higher. Similar findings have been obtained with titanium alloys tested at higher temperatures[8].

Comparison of the test results at 150°C for melt *B* (Fig. 4) and for melt *A* (Fig. 2) shows some qualitative differences, although the creep curves for both are of a similar shape. In particular, there is a considerable difference, as a result of mechanical treatment, in the testing times at which maximum creep rate and absolute values of permanent elongation are obtained. At the stress level of 25 kg/mm², the specimen from melt *A* fractured after 120 hr, whereas the forged and annealed specimen from melt *B* had only an elongation of 6% under the same condition, and was not ruptured even after 1000 hr. From the shape of this creep curve, rupture could be expected after about 10,000 hr. By contrast, however, rupture occurred after about 280 hr with the forged and drawn specimen, and as early as 22 hr with the sheet specimen, both taken from melt *B*. The findings are similar as regards the position of the region of maximum creep rate. For melt *B*, with a stress of about 17·25 kg/mm², a marked increase in elongation was obtained after about 50 hr for material in the forged condition, after 10 hr with the forged and drawn specimen, and after 2 hr with the sheet specimen. On the other hand, with melt *A* in the forged condition, the region of maximum creep was reached after 2 hr at a stress of 17·5 kg/mm².

Metallographic examination established a grain size of 450 μ^2 for melt *A*, and 250 μ^2 for melt *B*. Both melts showed precipitations of a second phase (β-titanium), stabilized by the iron content. The differences in fracture times can probably be explained by the differences in grain size. After preliminary cold-working, the precipitations were no longer present; moreover, for both the cold-drawn and hot-rolled materials, the grain size is greater than for the forged condition in the case of melt *B*. After cold-drawing, the grain size is about 500 μ^2, so that it is only slightly greater than that of the forged material from melt *A*. The corresponding elongation curves (Figs. 2 and 4) for these two materials show some measure of agreement as regards maximum creep rate and fracture times. However, the cumulative value of elongation after passing the creep-rate maximum is greater for melt *B* than for melt *A*, even at low stress levels, owing to the higher oxygen content of melt *B*. For the rolled sheet specimens, despite their smaller grain size, the fracture times and the maximum creep rates occur earlier than for the drawn specimens. Presumably, in this instance, in addition to grain size, the recrystallization structure has an effect.

The creep behaviour of titanium from melts *C* and *D*, (grain size 550 μ^2), which had a low content of impurities and hence a lower strength, was tested at 24°C and at 150°C. At both test temperatures, the stresses required to reach specified elongation values were considerably lower than for melts *A* and *B*, which had a higher initial strength. Maximum creep rate still occurred at room temperature, but was less pronounced than in the tests on the previous melts; the increased rise in elongation (most pronounced at 10 kg/mm² and 150°C) extended over a longer interval of time. For some specimens, the elongation curve did not have a smooth trend upwards. Thus, for instance, a specimen from melt *D*, tested at a stress of 9·5 kg/mm², showed two regions of maximum creep rate. At high test temperatures, melts *C* and *D* also exhibited a fairly high initial elongation immediately after load application, this being followed by a region with a very low creep rate.

Evaluation of Test Results

Fig. 5 shows curves of creep rupture and elongation for specimens from melt *A*, as derived from the results of the previous tests described. Some of the 10,000-hr

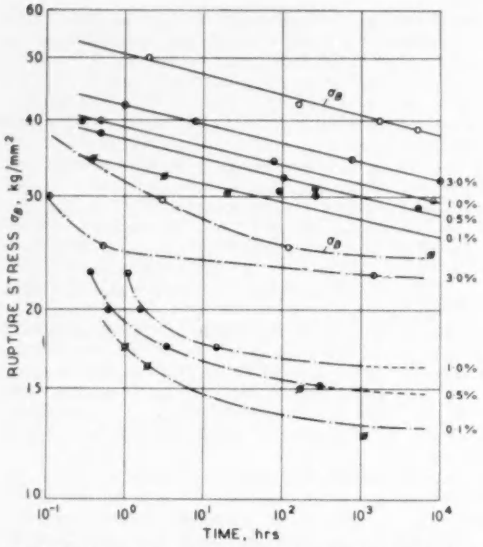


Fig. 5. Creep rupture and elongation of specimens from melt *A* as functions of time at 24°C (solid lines) and at 150°C (chain-dotted lines).

values were determined by extrapolation, which is permissible, in view of the very slight changes occurring beyond 1000 hr. At room temperature, these curves are straight lines to a first approximation, whereas at 150°C the curves fall off fairly rapidly at first and then tend to become horizontal. The decrease in stress is relatively small after a 1000-hr exposure. At higher test temperatures, the final elongation is reached much more rapidly, and the curves then remain practically horizontal, as previously.

For melts *C* and *D*, which had lower strengths, the

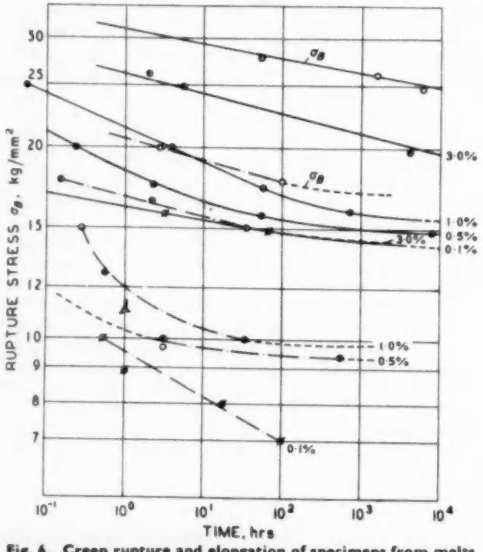


Fig. 6. Creep rupture and elongation of specimens from melts *C* and *D* as functions of time at 24°C (solid lines) and at 150°C (chain-dotted lines).

curves follow a substantially similar pattern (Fig. 6). At room temperature, however, straight lines are obtained only for the curve of creep rupture stress and for the 3% elongation. The curves for lower values of elongation show a rapid initial decrease, like most of the curves for 150°C, and then tend to flatten out asymptotically.

A comparison of 1000-hr values of 1% proof stress is of interest. For melt *A*, the 1% proof stress at 1000 hr decreases from 30·5 kg/mm² at room temperature to 17 kg/mm² at 150°C. For melts *C* and *D*, the corresponding values are 15·5 kg/mm² at room temperature and 9·5 kg/mm² at 150°C. Between 150° and 300°C, elongation shows only a fairly small decrease. Thus, at 300°C, the 1% proof stress at 1000 hr has a value of 14 kg/mm² for melt *A*, and remains at approximately 9·5 kg/mm² for melts *C* and *D*.

Tests were carried out to determine the effects of different treatments on elongation for specimens from melts *A* and *B*. Depending on the type of treatment, the creep rupture limits of specimens from melt *B*, tested at 150°C, varied from 22·5 kg/mm² to approximately 26 kg/mm², the lowest value being obtained with the rolled sheet specimens, and the highest with the fine-grain forged material. It is worth emphasising, therefore, that the creep rupture strength is less affected by the content of impurities than by treatment and grain size. The effect of impurities was more marked in the case of elongation but, here again, the effect of the mechanical treatment was predominant. Owing to the steeper rise of elongation in the region of maximum creep rate, the curves of elongation decreased further, even with longer testing periods for melt *B*, with its higher oxygen content, whereas melt *A*, with a lower oxygen content, also showed smaller elongations after passing through the region of maximum creep rate. The values of 1% proof stress at 1000 hr for the various treatments ranged from 13·5 kg/mm² for the rolled sheet specimen to 18 kg/mm² for the fine-grain forged material.

It might have been expected that the effect of impurities on strength would decrease rapidly at increased temperatures, in view of the high diffusivity of these elements, so that the various grades of titanium would show practically no differences in strength at high temperatures. The present results, however, show that this is not so, and that the higher content of impurities exercises a strengthening effect at high temperatures.

Test duration had no noticeable effect on the ductility of the specimens tested up to rupture. Ductility seems to be more sensitive to slight differences in texture, so that the differences in fracture times are in this respect of secondary importance.

REFERENCES

(1) A. D. McQuillan and M. K. McQuillan: "Titanium", London, 1956, p. 352 *et seq.*

(2) H. Adenstedt: *Metal Progress*, Vol. 56, 1949, pp. 658–560.

(3) D. R. Luster, W. W. Wentz, and D. W. Kaufmann: *Materials & Methods*, Vol. 37, 1953, pp. 100–103.

(4) W. R. Kiessel and M. J. Sinnot: *J. Metals*, Vol. 5, 1953, pp. 331–338.

(5) F. D. Rosi and F. C. Perkins: *Trans. Amer. Soc. Metals*, Vol. 45, 1953, pp. 972–992.

(6) A. T. Churchman: *Acta Metallurgica*, Vol. 3, 1955, pp. 22–29

(7) H. Scholl and W. Knorr: *Acta Metallurgica*, Vol. 9, 1961, pp. 61–63.

W. Knorr: *Techn. Mitt. Krupp:* Vol. 17, 1959, pp. 111–123.

The Ultrasonic Welding of Heat-Resistant Metals

By N. E. Weare and R. E. Monroe

From *Welding Journal*, U.S.A.,
Vol. 40, No. 8, August 1961,
pp. 351s–358s, 15 illustrations.

Although many of the problems involved in working with materials such as molybdenum and columbium have been solved, the joining of dissimilar-metal combinations still presents many problems. In this connection, ultrasonic welding offers a possible solution to the problem of welding refractory metals and of producing satisfactory weldments between dissimilar metals for high-temperature applications. For this reason, the research programme described in this paper was initiated.

To study the fundamentals of the process, as well as the joining of a number of heat-resistant materials, special equipment and instrumentation were developed. Factors influencing the formation of welds and their room-temperature properties were also studied. Bearing in mind the desirability of producing joints in various combinations of materials, so as to utilize the unique properties of the refractory metals only where required, certain materials were selected for specific investigation.

These materials comprised commercially pure titanium (0·020 in. thickness, hot-rolled and annealed, 188 DPH), arc-cast molybdenum containing 0·5% titanium (0·015 in thickness, rolled to a reduction of about 80% and stress-relieved, 296 DPH), commercially pure columbium (0·020 in. thickness, rolled and annealed, 83·6 DPH), AISI Type 316 stainless steel (0.018 in. thickness, cold-rolled, 135 DPH), Inconel (0·018 in. thickness, cold-rolled, 118 DPH), and high-purity iron (0·005 in. thickness, cold-rolled in excess of 90%, 165 DPH).

The special ultrasonic welding unit assembled for this investigation was designed to permit an ease of instrumentation not accomplished in commercially available equipment. The unit consisted of a 2·4-kW power oscillator and a 20-kcs water-cooled transducer mounted in a horizontal plane, so that welding-tip motion was parallel to the surface of the sheet being welded. Welding tips were mounted on the transducer coupling body, as shown in the block diagram in Fig. 1.

Clamping force was applied to the materials being welded by an air cylinder. Various weld-tip and anvil designs weres tudied, but these are not described here.

The welding unit was instrumented in a manner which permitted measurements of the welding variables, i.e., power, weld time, and clamping force. Previous investigators have measured power as R.F. watts delivered to the transducer. This method was not considered acceptable in this study, since power delivered to the weld tip is not a linear function of power delivered to the transducer. Also, the efficiency of power delivery to the weld tip was not known. Weld-tip displacement is a function of the power available for welding. For this reason, it was decided that power would be measured as actual weld-tip displacement during the weld cycle. This was accomplished by the use of a capacitance pick-up at the tip which detected changes in the air gap between the weld tip and a capacitance plate. Changes in the capacitance unbalanced one side of an inductively coupled dual oscillator circuit, resulting in a power transfer through their coupling circuit. A signal from teh coupling circuit was metered to give a measure of welding-tip displacement. Welding time was measured by a clock timer, and clamping force was determined from readings on a pressure gauge on the air cylinder. Weld tips were machined from Monel metal, which has good fatigue strength and is a good transmitter of ultrasonic energy. Mild-steel and drill-rod anvil materials were used.

The welding procedures adopted can be summarized as follows:—

(1) The materials were degreased with trichloroethylene and cleaned just prior to welding.

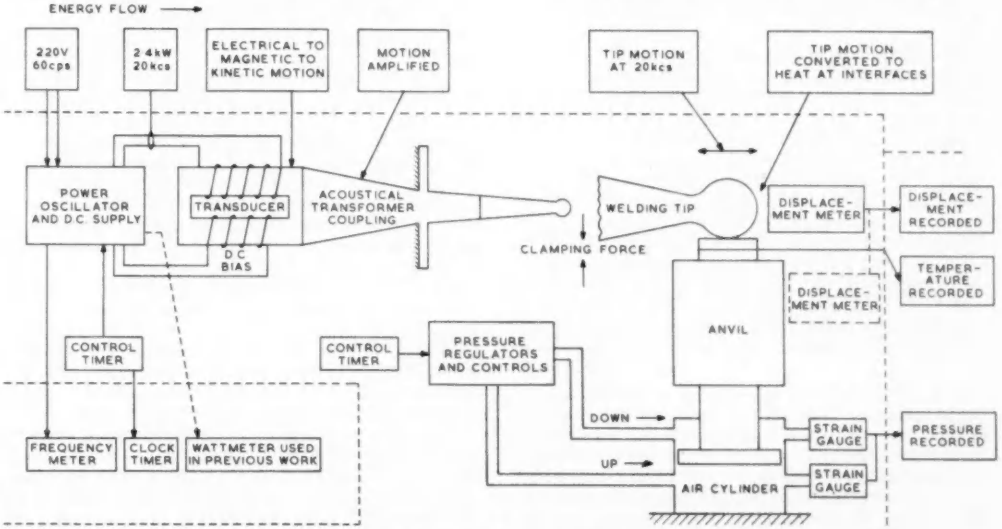


Fig. 1. Block diagram of the ultrasonic welding system used, showing instrumentation and energy flow.

(2) The sample to be welded was placed on the anvil and clamping force was applied to clamp the specimen between the tip and anvil.
(3) The capacitance-plate-displacement meter was adjusted to the proper air gap.
(4) The ultrasonic-energy cycle was activated for a preset time.
(5) A short period after the completion of this cycle, the clamping pressure was released and the weldment was removed.
(6) The weld tip and anvil were cleaned by abrading with fine emery paper.
(7) The weldment was then either broken apart to examine the bond, tested in a tension-shear or cross-tension test, or sectioned for metallographic examination.

It should be noted that the original intention was to determine the properties of the joints at room temperature and at elevated temperatures, and limited room-temperature strength data were obtained. However, metallographic examination indicated the presence of cracks at the edge of the bond in the refractory metals concerned. The elimination of cracking then assumed the primary role of the investigation.

Titanium to Stainless Steel

Welds between titanium and Type 316 stainless steel were studied more thoroughly than those between any of the other heat-resistant joints. Initial studies were made with a weld tip of $\frac{1}{16}$ in. radius and an anvil with a surface radius of 3 in., and it was found that this weld tip caused severe deformation of the weldment and contributed to the cracking previously mentioned. Even though cracking was found in nearly all welds made with the weld tip of $\frac{1}{16}$ in. radius, relationships were established between weld strength (tensile-shear load at failure) and tip displacement, clamping force, and welding time, as shown in Figs. 2, 3, and 4.

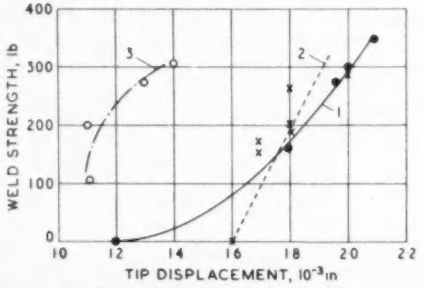


Fig. 2. Weld strength as a function of tip displacement for weldments of titanium to Type 316 stainless steel and of Type 316 stainless steel to titanium.
(1) Titanium to stainless steel. Clamping force = 150 lb, weld-tip radius = $\frac{1}{16}$ in., anvil radius = 3 in.
(2) Stainless steel to titanium. Clamping force = 150 lb, weld-tip radius = $\frac{1}{16}$ in., anvil radius = 3 in.
(3) Stainless steel to titanium. Clamping force = 200 lb, weld-tip radius = 3 in., flat anvil.

Fig. 2 shows weld strength as a function of tip displacement for welds of titanium to the stainless steel, i.e., with the titanium directly beneath the weld tip and the stainless steel against the anvil, and also for welds of the stainless steel to titanium, i.e., with the stainless steel beneath the tip and the titanium against the anvil. As can be seen, the particular material under the weld tip has no effect on joint strength.

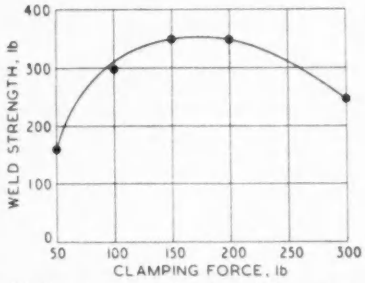


Fig. 3. Weld strength as a function of clamping force for weldments of titanium to Type 316 stainless steel, using a tip displacement of 0·0021 to 0·0022 in., a weld-tip radius of $\frac{1}{16}$ in., and an anvil radius of 3 in.

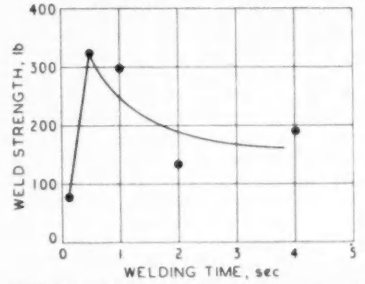


Fig. 4. Weld strength as a function of welding time for weldments of titanium to Type 316 stainless steel, using a tip displacement of 0·0018 to 0·0020 in., a weld-tip radius of $\frac{1}{16}$ in., an anvil radius of 3 in., and a clamping force of 150 lb.

One fact noted when the bond area of the fractured tensile-shear specimens was measured was that there appeared to be an optimum weld area at which the highest weld strengths were experienced. Strengths increased linearly with bond area to the optimum and then dropped off, probably due to severe cracking at conditions which produce a larger apparent bond area. In nearly all welds made between titanium and stainless steel at high tip displacements and utilizing the $\frac{1}{16}$-in. tip radius, slivers of titanium were extruded out from the bond in a direction normal to the direction of tip displacement, as illustated by Fig. 5. The titanium was heated during the weld cycle to a temperature at which it had become highly plastic, so that material could be extruded out from the periphery of the bond area. It will be noted from Fig. 5 that, in the central area of the bond, the original sheet surface is still intact and the titanium surface is imprinted on the stainless-steel surface. The annular area surrounding this central zone is the area in which the clamping force was low enough to allow slippage.

A number of welds were also made between titanium and the stainless steel, using a weld tip with a radius of 3 in., the effect of this tip on weld strength being included in Fig. 2. Larger bond areas with less cracking were obtained when a tip of 3-in. radius was employed. The ratio of cross-tension strength to tensile-shear strength for this weldment was about 0·1.

Extensive metallographic examinations were made of weldments of titanium to stainless steel. Of particular interest was the area near the edge of the bond where cracking took place. A second phase was found in the titanium in the areas surrounding the cracks (Fig. 6). This phase has been identified as titanium hydride. If

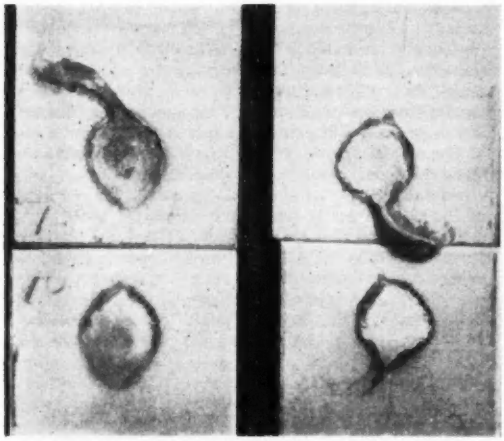


Fig. 5. Fractured ultrasonic welds between titanium (upper part of illustration) and Type 316 stainless-steel (lower part of illustration), in the case of (left) a weldment of the stainless steel to titanium, and (right) a weldment of titanium to the stainless steel. (×4)
Tip displacement = 0·0018 to 0·0020 in., tip radius = $\frac{1}{4}$ in., clamping force = 150 lb, welding time = 1 sec. The direction of tip motion is horizontal with respect to the illustration.

this is so, hydrogen embrittlement may be contributing to the cracking of these joints. Hydrogen may migrate from cooler unstressed titanium to the warmer highly stressed areas at the edge of the bond. Other investigators have commented on the break-up of pearlite and the diffusion of carbon in welding low-carbon steel. The hydrogen content of this sheet was reported as 97 ppm, which is below the amount required to cause embrittlement in fusion welds. If this analysis is correct, the hydrogen content of titanium is much more critical for ultrasonic welding.

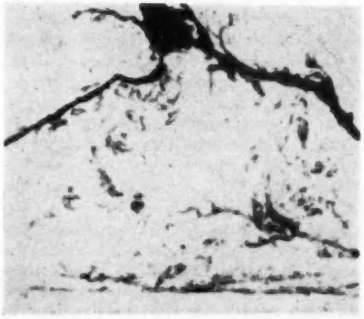


Fig. 6. Structure at the edge of an ultrasonic weld between titanium (above the crack) and Type 316 stainless steel, showing cracks and the formation of a second phase. (×250).
Tip displacement = 0·0031 in., tip radius = $\frac{1}{4}$ in., clamping force = 150 lb, welding time = 1 sec.

During the course of the study of weldments containing titanium, several titanium-to-titanium welds were made with the purpose of determining whether the second phase found in joints containing stainless steel was due to the presence of stainless steel. This second phase was also noted in the titanium-to-titanium welds, especially at the edge of the bond where cracking took place. Ultrasonic welds in titanium had tensile-shear breaking loads of 440 lb and cross-tension loads of 105 lb, giving a cross-tension to tension-shear strength ratio of 0·24. Failures occurred by shearing the weld nugget from both sheets. These values are equivalent to those expected from resistance spot welds in this type and thickness of titanium.

Molybdenum to Molybdenum

Welding of molybdenum to molybdenum was effected with a welding tip of 3 in. radius, in conjunction with a flat anvil, using tip displacements between 0·0007 and 0·0016 in., clamping forces between 200 and 300 lb, and welding times between 0·5 and 2 sec.

It was found that the properties of the joints produced were very erratic and that their strengths were extremely low. The extent of the internal deformation in molybdenum welds was much greater than for any other material studied. Molybdenum possessed the highest modulus of elasticity, so that given strains were accompanied by higher stresses than for the other materials. The existence of these high stresses may explain the greater amount of deformation found in this type of weldment. The great degree of cracking in molybdenum is probably related to its low elongation.

Ultrasonic spot welds in molybdenum were very weak. Tensile-shear loads at failure were generally below 60 lb, and cross-tension loads were nil. The best welds were produced with a tip displacement of 0·00115 in., a clamping force of 300 lb, and a welding time of 2 sec. Other investigators have also noted low strengths and extensive interior deformation in the case of ultrasonic spot welds in molybdenum. The molybdenum used during this investigation possessed a very rough surface. If the surface were polished or the gross roughness were removed, an improvement in weldment properties might result. Further improvements in molybdenum weldments might be realized by preheating, so as to lower the mechanical properties and increase ductility, and by using high clamping pressures and a faster energy input.

Molybdenum to Stainless Steel

Tests on the strength of welds between molybdenum and Type 316 stainless steel showed that, in many instances, the tensile-shear fracture occurred by tears along the laminations in the molybdenum sheet, these laminations being common in all molybdenum sheet which has been severly cold-worked. Tensile-shear loads up to 190 lb were determined for the joint, although loads in the neighbourhood of 160 to 170 lb were more common. Cross-tension strengths were nil.

Cracking of the molybdenum was a problem associated with this type of weldment and appeared to consist of opening up of the laminations in the sheet. A typical weld interface was nearly an unbroken line, and no diffusion or formation of intermetallic compounds were found in any section examined. In this type of joint, sliding apparently took place over the entire bond area during welding, removing the asperities of the molybdenum and stainless steel and accounting for the rather smooth joint formed.

Columbium to Stainless Steel

Several welds were made to determine the room-temperature properties of columbium to Type 316 stainless-steel weldments. Few data were available to determine the relationship between weld strength and the welding variables. The highest strength welds were

produced between columbium and the stainless steel with a tip displacement of approximately 0·0012 in., a clamping force of 200 lb, and a welding time of 1 sec. The maximum tensile-shear loads of the columbium-stainless-steel joint were in the neighbourhood of 90 to 100 lb, and cross-tension loads were about 5 lb.

Metallographic examination indicated that cracking was not as serious a problem as in other joints under study, although some cracking did occur. The softer columbium tended to flow into the depressions in the stainless-steel surface, while the columbium in the neighbourhood of the interface was plastically deformed during welding. The centre portion of the bond area apparently was nearly stationary during welding, since the imprint of the stainless steel could be clearly seen on the columbium surface. Slippage took place in the area surrounding the central portion of the bond.

Columbium to Iron to Stainless Steel

Weldments of columbium to high-purity iron to Type 316 stainless steel were made in one operation and were, in fact, the easiest of all heat-resistant weldments to produce. As in the case of the other weldments, the effects of tip displacement, clamping force, and welding time on weld strength were determined, optimum weld strengths being obtained with a tip displacement of 0·0015 in., a clamping force of from 200 to 300 lb, and a welding time of 0·5 sec. Maximum tensile-shear loads at failure of 175 lb were obtained, with cross-tension loads of about 50 lb, the ratio of cross-tension to tensile-shear strength for this type of weldment being 0·29.

The use of the iron insert improves the properties of stainless-steel to columbium welds, especially the cross-tension strength. Iron was used primarily because it is believed to be a barrier to the diffusion which might occur between columbium and stainless steel. At these strength values, failure occured by tearing the nugget from the iron on both the columbium and iron interfaces. This improved cross-tension strength indicates that a good bond was attained at both interfaces.

Failures of this type of joint nearly always occurred at the junction of stainless-steel and iron. Further improvement in joint strength might be obtained by plating the iron onto the stainless steel prior to welding, to produce a better bond at the stainless-steel to iron interface. Again, it was apparent that sliding did not take place in the central zone of the bond area, and slippage occurred in the annulus surrounding this central zone, although this area was smaller than for the stainless-steel to columbium welds.

Metallographic examination did not show any evidence of cracking in this joint. Evidently, the iron absorbed the strain, so as to prevent cracking of the columbium. Micrographs of welds near the centre of the bond showed that good bonds were apparently obtained at both interfaces. The high-purity iron sheet possessed a severely cold-worked structure prior to welding, and iron in this joint had been recrystallizing during welding, indicating that interfacial temperature exceeded 800° F. Near the edge of the bond it was noted that the iron had been severely cold-worked and the columbium surface had been broken up. Pieces of columbium were seen in the iron, even in the vicinity of the stainless-steel surface. If melting did not take place in this area, the indication is that extremely high alternating stresses are found in this area of an ultrasonic weld and that the iron was in a highly plastic condition.

Columbium to Inconel

Columbium-Inconel welds were made to determine the effect of welding variables on the properties of joints, the highest-strength welds being produced with a tip displacement of about 0·001 in., a clamping force of 250 lb, and a welding time of 2 sec. Tensile-shear loads in the neighbourhood of 130 to 145 lb were common, while cross-tension loads were about 10 lb.

Metallographic examination indicated severe cracking of the columbium at the edge of the bond area. The cracks were normal to the sheet surface and had the appearance of being tears in the sheet which might be expected in a ductile metal such as columbium. This type of joint appeared to be very similar in appearance to the columbium-stainless steel joint. The softer columbium was partially forced into the depressions in the Inconel surface.

The appearance of the fracture face in this joint was similar to that found in the columbium-stainless steel welds. Apparently, little or no relative sliding occurred at the centre of the bond, since the Inconel surface was imprinted on the columbium. Slippage occurred in the annulus surrounding the central portions.

Analysis of Results

The major problem encountered in the welding of the heat-resistant materials was the presence of cracks in the majority of welds. These cracks were not apparent as long as only tensile-shear samples were tested. Only metallographic examination showed the presence of the cracks and indicated the seriousness of the problem.

During one-half of a cycle in ultrasonic welding, a tear may be opened as a result of tension stresses at the sheet surface, if the strain is sufficiently high. The crack may then propagate as a fatigue failure during the remainder of the welding time. Metallographic examination indicated that the degree of cracking increased with tip displacement and welding time and was independent of clamping force in the range studied. Tip displacement governs the amount of stress present at the edge of the weld area. If displacement were lowered below a value at which a crack would form, strong bonds might be obtained at higher clamping forces and slightly longer welding times. Cracking also was lessened by the use of larger tip radii. Higher powers and clamping forces than those used in this work might aid in eliminating cracking.

The great amount of deformation which took place during the welding of molybdenum was not readily explained. This study indicated the need to investigate further the effects of the mechanical properties of the materials being welded. It appears that the amount of deformation may be related to the modulus of elasticity, since deformation seems to increase with increasing modulus.

One reason for an interest in the use of ultrasonic welding of heat-resistant metals was the possible welding of dissimilar-metal combinations with no formation of brittle intermetallic compounds. No intermetallic compounds were noted in the welds examined metallographically. Diffusion and the formation of intermetallic components might occur in some of the joints if they were subjected to elevated temperature for extended periods of time.

One other factor worth noting in connection with most of the ultrasonic welds in the heat-resistant alloys

studied during the programme was the low cross-tension strength. Unless this cross-tension strength is raised, it is difficult to see any wide application of ultrasonic welding to dissimilar-metal joints in heat-resistant alloys for aircraft use. The cross-tension, as well as the tensile-shear strength, of the joint between stainless steel and columbium was greatly improved by placing an iron insert in the interface. The low-strength welds in the stainless-steel to columbium weldments may have been a result of the difference in mechanical properties. Ultrasonic energy may have been dissipated by deformation of the columbium, without causing sliding to take place in the interface. The iron insert may have lessened the gradient in mechanical properties and allowed sufficient sliding to take place at the interface to produce good metal-to-metal contact and thus form a strong weld. Molybdenum-to-molybdenum joints may be improved by placing a soft metal foil in the interface.

The Fatigue Behaviour of Resistance Strain-Gauges

By C. ROHRBACH and N. CZAIKA

From *Materialprüfung*, Germany,
Vol. 3, No. 4, April 20, 1961,
pp. 125–136, 20 illustrations.

UNDER alternating strains of 0·1% or more, resistance strain-gauges suffer first a significant positive zero drift, then a distortion of their response curve, and finally a fatigue fracture in their grid or terminal leads. Superposition of a static mean strain does not affect the zero drift, but a positive mean strain may accelerate fatigue fracture in the grid. It will therefore be appreciated that the fatigue behaviour of strain-gauges is of special interest when they are used for dynamic or repeated static measurements. For this reason, an investigation has been carried out, as described in this paper, to determine how the sensitivity and zero position of strain-gauges change during the course of alternating stresses, and also the time to failure.

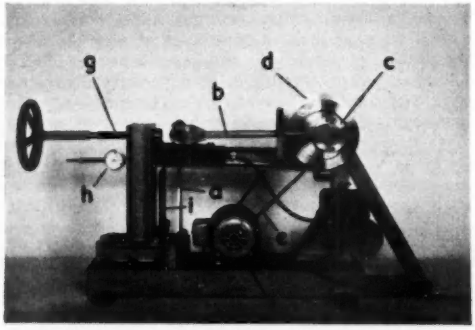


Fig. 1. Cantilever bending fatigue testing machine for preset static and dynamic strain conditions.
(a) Tapered cantilever beam.
(b) Connecting rod.
(c) Eccentric.
(d) Belt pulley.
(e) Vee belt.
(f) Motor.
(g) Mean-strain adjusting spindle.
(h) Dial gauge.
(i) Plate for compensating gauges.

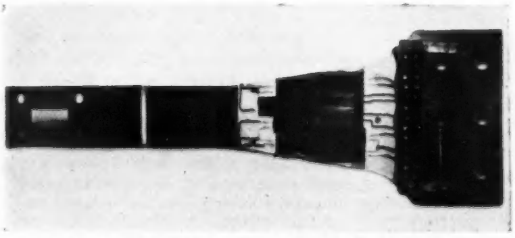


Fig. 2. Tapered cantilever with fitted strain-gauges.

For the purpose of this investigation, use was made of an eccentric-driven fatigue testing machine (Fig. 1) which imposes preset bending-strain vibrations on a tapered cantilever beam (Fig. 2), fitted with the different types of strain-gauges to be tested, as shown in Table I. During each test run, the gauge-factor in tension and compression and the mean strain indicated by the gauge are measured at intervals and the gauge response oscillations observed and registered continuously from the moment the first distortions are seen. Finally, the position of fatigue fracture is found by a microscope or by sectional testing for electrical continuity. The peak strains imposed on the gauges were $\pm 0{\cdot}025$, $\pm 0{\cdot}05$, $\pm 0{\cdot}1$, and $\pm 0{\cdot}2\%$; in addition, one type of gauge (Hottinger 20/600 FB 3) was tested under alternating peak strains of 0·1 and 0·2% with superimposed static mean strains varying from $-0{\cdot}3$ to $+0{\cdot}3\%$. The tests were run at room temperature at 720 cpm.

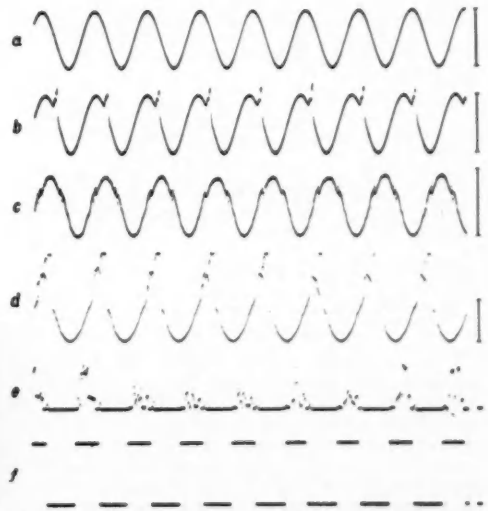


Fig. 3. Typical gauge-response oscillations during various stages of fatigue tests, the vertical calibration marks indicating the correct response range of about 0·4%.

TABLE I: TYPES OF STRAIN-GAUGES INVESTIGATED

Manufacturer	Designation	Type of Cement	Drying Procedure	Grid Material	Gauge-Factor	Type of Gauge
Hottinger	200/600 FB 1	BC 60–35	2 hr at 80°C 2 hr at 120°C	Constantan	2·1	Zig-zag grid.
Hottinger	200/600 FB 3	BC 60–35	2 hr at 80°C 2 hr at 120°C	Constantan	2·1	Zig-zag grid with strain-relieving wire loop between grid and leads.
Hottinger	20/120 FB 4 S	BC 60–35	2 hr at 80°C 2 hr at 120°C	Special wire	2·1	Zig-zag grid with strain-relieving strips.
Hottinger (Baldwin)	CB–1	BC 60–35	2 hr at 80°C 2 hr at 120°C	Iso-Elastic	3·5	Zig-zag grid.
Huggenberger	BP 1/120	Vernis or Cement KU	4 hr at 20°C 20 hr at 40°C 4 hr at 60°C	Unknown	2·5	Parallel wires with welded cross-bars.
Saunders-Roe	M–L 229	Araldite B	14 hr at 120°C	Ferry	2·1	Foil gauge.
—	—	—	—	Constantan	2·1	Very thin metal foil.

Response Distortions

In the course of a fatigue test, the gauge response oscillations were found to deteriorate as shown in Fig. 3. At first, the gauge reproduces faithfully the strain variations in the beam (Fig. 3a). Then, after a certain number of cycles which varies widely according to gauge type, strain amplitude, and mean strain, the first distortions appear at one point of the response curve (Fig. 3b), or at two points symmetrical about the tensile-strain peak, as shown in Fig. 3c, in which it will be noted that the waveform also changes.

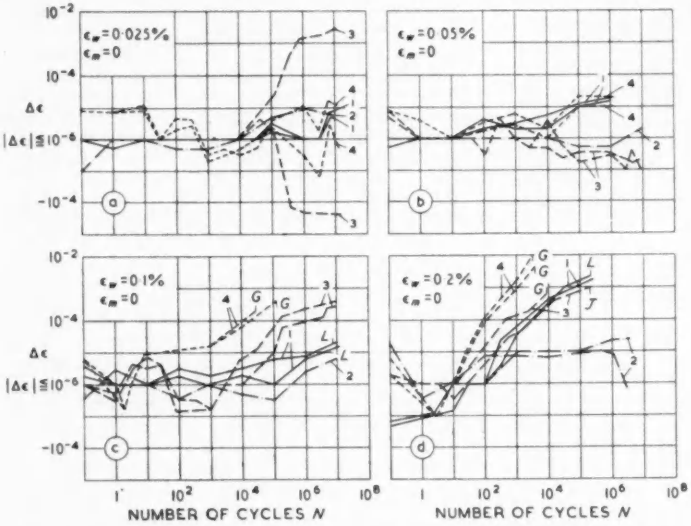


Fig. 4. Zero drift $\Delta\varepsilon$ as a function of the number of cycles N for four types of strain-gauges under zero mean strain ε_m and various strain amplitudes ε_a.

(1) Hottinger 20/600 FB 1 gauge.
(2) Hottinger 20/120 FB 4 S gauge.
(3) Huggenberger BP1/120 gauge.
(4) Saunders-Roe M-L 229 gauge.
(G) Fracture in grid.
(J) Fracture in soldered joint.
(L) Fracture in terminal leads.

Further cycles rapidly increase the distortions, especially on the tension side (Figs. 3d and 3e), the change from Fig. 3b or 3c to Fig. 3e usually occurring within less than one power of ten in the number of cycles. Next, the response changes until only two extreme values are recorded, i.e., the gauge resistance and the open gauge circuit (Fig. 3f). The waveforms during the compressive part of the cycle are now also distorted, though this distortion is concealed by the small amplification of the oscillograms in Fig. 3f. The time of transition from Fig. 3e to 3f varies widely with individual gauges. Finally, the open-circuit line extends progressively until the whole response consists of one line, the gauge circuit remaining permanently open.

Under the microscope, typical fatigue fractures can be seen. During the stage shown in Fig. 3f, the gauge acts as a switch, making contact under compressive strains only. Cracks already exist during the stage shown in Fig. 3b or 3c, and are propagated during subsequent stages, closing at least partially during the compressive half of the cycle. A model test undertaken to investigate the change in resistance and strain with increasing crack length supports this interpretation.

Changes in Gauge-Factor

During the first stage of testing (Fig. 3a), no change in gauge-factor was observed in excess of the overall measuring accuracy of $\pm 1\%$, thus contradicting the results of previous work*. Each sinusoidal part of the response curve at the stage of Fig. 3c still shows the same resistance/strain ratio; another value is apparent only in those parts which exhibit jumps and distortions.

* K. R. MASLEN and J. G. SCOTT: "Some Characteristics of Foil Strain-Gauges". *R. A. E. Technical Note* INSTN 134, p. 9.

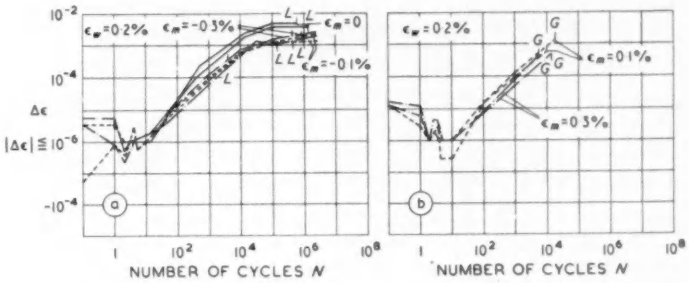


Fig. 5. Drift of a Hottinger 20/600 FB 3 gauge with a strain amplitude ε_w of 0·2% and various values of mean strain ε_m.

(G) Fracture in grid.
(L) Fracture in terminal leads.

A change in gauge-factor as a result of deteriorating adhesion was observed with one gauge only and was therefore disregarded as a significant factor.

Zero Drift

Steady creep of strain-gauges occurs only when the mean strain is not zero. Previous investigations† have shown that this creep is less than 2% of the (mean) strain applied and, in view of the results described below, this contribution to drift can be ignored. Since the gauge-factor remains constant, measurement of the mean or zero strain actually reveals the drift of the gauge (Figs. 4 and 5). There can be an appreciable positive or negative drift of individual gauges, even with a strain amplitude ε_w of 0·025% (Fig. 4a), but the results have a wide scatter and a consistent average for a number of gauges cannot be discerned for values of strain amplitude up to 0·05% (Fig. 4b). With $\varepsilon_w = 0{\cdot}1\%$ (Fig. 4c), the Saunders-Roe M–L 229 foil gauge and the Huggenberger BP 1/120 gauge with cross-bars begin to show a consistent positive drift, while only one type of gauge remains free from consistent drift with $\varepsilon_w = 0{\cdot}2\%$ (Fig. 4d). According to Fig. 5, which shows the drift of a Hottinger type 20/600 FB 3 gauge with a value of ε_w of 0·2% and various values of mean strain ε_m, neither a positive nor a negative mean strain noticeably influences drift, though this may not be generally valid.

Since the insulation resistance of the gauges does not decrease below permissible values and creep is negligible, the drift must be caused by changes in the grid wire or foil. On the other hand, the drift is connected neither with the response distortions (Fig. 3), which begin to appear at an arbitrary stage of drift, nor with crack formation or propagation because (a) foil gauges show no incipient cracks during the period of noticeable zero drift, (b) drift progresses more linearly than would be expected from the resistance change due to increasing cross-sectional restriction as the crack progresses, and (c) the drift in Fig. 5 is unaffected by the mean strain, whereas the life is shortened considerably by a positive mean strain.

In order to elucidate the causes of zero drift, two Hottinger type 20/600 FB 3 gauges were first fatigued at ±0·2% strain amplitude until they showed a zero drift corresponding to 0·18% strain; together with two unstrained gauges they were then heated in a vacuum for 120 hr at 122°C and for 90 hr at 200°C. The unstrained gauges showed a slight negative zero drift, while the fatigued gauges showed a very pronounced negative drift, which in the end compensated for about 90% of the positive drift due to fatigue, almost completely restoring the original electrical conductivity of the wire. Consequently, zero drift appears to be caused almost entirely by microscopic or submicroscopic metallurgical changes in the wire or foil.

† C. ROHRBACH and N. CZAIKA: "Creep of Resistance Strain-Gauges under Static Tension"; *Arch. Techn. Messen*, J 135 (16/18); also, *The Engineers' Digest*, January 1961, pp. 81-84.

Fatigue Fractures

Possible causes of strain concentration are shown in Fig. 6. In actual fact, fractures in wire strain-gauges took place near the positions of stress concentration shown in Figs. 6a and 6b. The terminal leads of all these gauges had been bent upwards near the ends of the carrier material, so that the fractures often seen at these points were avoided and all the observed fractures in the terminal leads took place in the remaining cemented portions. No preferred points of fracture could be discovered in the Huggenberger BP 1/120 gauge with welded cross-bars. In the foil gauges tested, even the vicinity of deep notches, as shown in Fig. 6c, did not lead to premature failure.

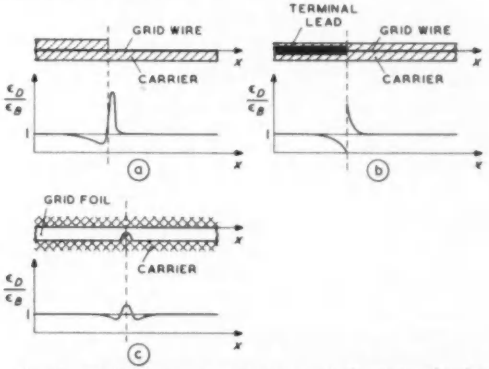


Fig. 6. Strain raisers in a resistance strain-gauge, showing ratio of strain ε_D of the wire or foil and strain ε_B of the structural member.

(a) Sudden change in carrier thickness (longitudinal section).
(b) Connection of grid wire to terminal lead (longitudinal section).
(c) Notch in foil (plan view).

From Figs. 4 and 5, the conclusions derived can be summarized as follows:—

(a) No fractures occurred at strain amplitudes ε_w of ±0·05% or less, even with a mean tensile strain ε_m of up to 0·3%.
(b) At strain amplitudes of ±0·1%, the foil grids fractured after 10^5 cycles, whereas the wire strain-gauges fractured after 10^7 cycles in the terminal leads.

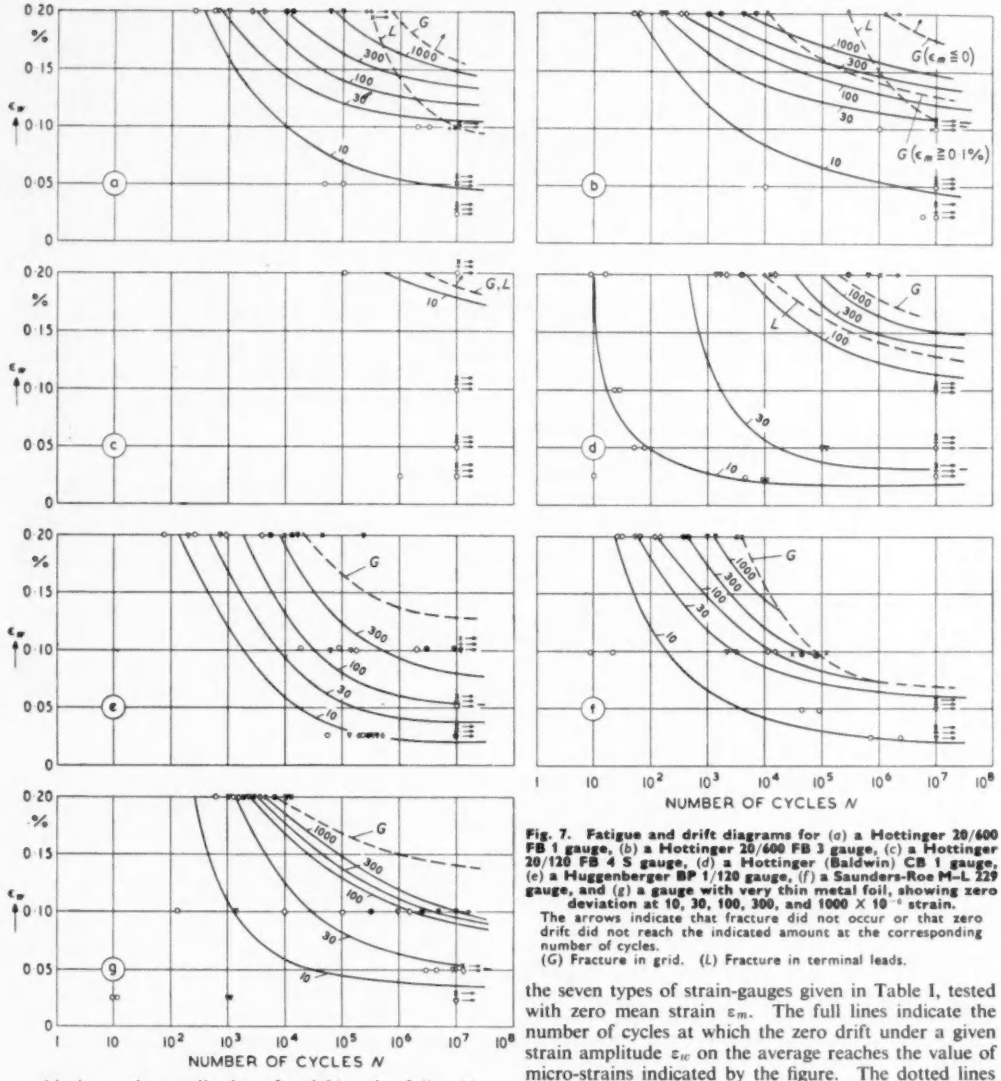


Fig. 7. Fatigue and drift diagrams for (*a*) a Hottinger 20/600 FB 1 gauge, (*b*) a Hottinger 20/600 FB 3 gauge, (*c*) a Hottinger 20/120 FB 4 S gauge, (*d*) a Hottinger (Baldwin) CB 1 gauge, (*e*) a Huggenberger BP 1/120 gauge, (*f*) a Saunders-Roe M–L 229 gauge, and (*g*) a gauge with very thin metal foil, showing zero deviation at 10, 30, 100, 300, and 1000 × 10^{-6} strain.
The arrows indicate that fracture did not occur or that zero drift did not reach the indicated amount at the corresponding number of cycles.
(*G*) Fracture in grid. (*L*) Fracture in terminal leads.

(c) At strain amplitudes of $\pm 0{\cdot}2\%$, the foil grids fractured after less than 10^4 cycles, and only the special Hottinger type 20/120 FB 4 S gauges survived 10^6 cycles.

(d) Under a strain amplitude ε_w of 0·2% and a zero or compressive mean strain up to 0·3%, the Hottinger type 20/600 FB 3 gauge fractured in the terminal leads after rather less than 10^6 cycles, irrespective of the magnitude of the mean strain ε_m imposed. Under a strain amplitude of 0·2% and a mean tensile strain of 0·1% or more, the grid wire of this gauge fractured after about 10^4 cycles.

Fatigue and Drift Diagrams

Fig. 7 shows test results for zero drift and fracture of the seven types of strain-gauges given in Table I, tested with zero mean strain ε_m. The full lines indicate the number of cycles at which the zero drift under a given strain amplitude ε_w on the average reaches the value of micro-strains indicated by the figure. The dotted lines indicate when fracture in the leads (*L*) or in the grid (*G*) occurs for a given value of ε_w. Since the test results have pronounced scatter, the curves cannot be regarded as very reliable, and a much greater number of strain gauges would have to be tested in order to give reliable average drift and fatigue curves. However, the curves provide at least a technical lead to the fatigue behaviour of various types of strain gauges and suggest a choice of gauge for fatigue conditions and certain possible improvements. For the Hottinger type 20/600 FB 3 gauge, the drift curves and the curve *L* for the leads in Fig. 7 are also valid for non-zero positive and negative mean strains ε_m; only curve *G* for the grid is lowered by a positive mean strain. It cannot yet be stated whether other types of gauges exhibit a similar behaviour under non-zero mean strains.

Methods of Generating and Heating Plasma

By M. F. WOLFF

From *Electronics*, U.S.A.,
Vol. 34, No. 28, July 14, 1961,
pp. 47–53, 7 illustrations.

AT present, the term plasma defines any mixture of particles, some of which are charged, whose spatial dimension exceeds the Debye length and where the percentage of the mixture ionized contains an approximately equal number of positive and negative particles, so that the overall aggregate is electrically neutral. The Debye length (also called the Debye shielding distance) is a measure of the distance at which a given negative particle is shielded by the surrounding positive particles. In c.g.s. units, the Debye length is expressed as $(kT/4\pi ne^2)^{\frac{1}{2}}$, where k is Boltzmann's constant, T is the kinetic temperature, n is the electron density, and e is the charge on an electron.

From this definition, it can be seen that plasma need not be restricted to gases; in fact, there can be two kinds of plasma in solids. The first type is where there are either electrons and positively charged donors, or holes and negatively charged acceptors. The second type of plasma occurs in an intrinsic semiconductor where there are only holes and electrons. Generally, however, plasma describes a gas which, in addition to meeting the criteria given above, is in such a state of ionization that it becomes conductive enough to be affected by magnetic fields. At temperatures above 20,000°K, ionization is 100% for most gases, and there are no neutral particles—only positive ions and negative electrons. This completely ionized or "true" plasma is considered a fourth state of matter and is what is most frequently meant by the term plasma.

Plasma comprises more than 95% of matter in the universe, and its behaviour can be visualized as that of an electrically conductive fluid. The interaction of plasma with magnetic fields has long been studied in connection with the origin of stars, but, on earth, where lower temperatures have prevented its natural formation, interest in plasma has mainly been limited to its occurrence in gaseous discharges, e.g., in carbon arcs and fluorescent lamps. Recently, however, considerable research into plasma has taken place as a result of controlled thermonuclear programmes, missile re-entry studies, and work on power conversion.

Numerous techniques are available for supplying the energy to electrons in a gas to produce the ionization required to form a plasma, these techniques being both electromagnetic and non-electromagnetic. Electromagnetic techniques include the use of a.c. discharges, electromagnetic shock tubes, and electron beams, as well as techniques such as d.c. discharges that are primarily electrical. Non-electromagnetic techniques include the use of diaphragm shock-tubes and the contact ionization of caesium vapour.

Alternating-current discharges used in producing plasma include microwave and lower-frequency discharges. The latter generally range from around 0·1 to 10 Mcs and are employed for what is termed R.F. pre-ionization. Here, the gas, which may be initially exposed to ultra-violet or to X-ray radiation to obtain a trace of ionization, is subjected to peak power in the kilowatt range, producing an ionization of a few per cent. In Princeton's B-3 Stellarator, for example, a 250-kcs generator applies 200 V for 1 millisecond to achieve 7 to 8% ionization in hydrogen or helium.

One method of inducing an R.F. discharge is to use the gas as the secondary of a transformer. This is done, for example, in a technique developed at the U.S. Air Force Cambridge Research Laboratories for injecting plasma into a betatron. Here, 25 kW of pulsed R.F. power is applied to a single-turn coil surrounding a toroidal discharge vessel. The power source is a pulsed R.F. amplifier fed by an oscillator and direct-coupled to a tuned circuit consisting of the inducing coil in parallel with a tuning capacitor. Plate and screen voltages for the four parallel tetrodes in the amplifier are supplied by capacitor discharges lasting about 10 msec. Plasmas have been produced in various gases at pressures down to 8×10^{-7} mm Hg.

Another method is to use the gas as the dielectric of a capacitor by connecting an R.F. oscillator to electrodes across the tube containing the gas. In both methods, however, ionization occurs because the oscillatory motion of the electrons is transferred to random motion on collision with the gas atoms, the container, or the electrodes.

The microwave cavity technique is common for producing steady-state plasmas. The cavity is filled with gas and a discharge occurs when the frequency of the microwave field is adjusted to equal the resonant frequency of the cavity. This technique is useful at high pressures, defined as pressures where the collision frequency is of the order of the microwave frequency or higher. Typically, for 3000 Mcs with hydrogen or helium, this pressure might be in the range of fractions of a millimetre to tens of millimetres of mercury.

At low pressures (of the order of microns of mercury), steady-state plasmas with densities of 10^{11} to 10^{12} particles/cm^3, can be produced by cyclotron resonance heating in crossed microwave electric and static magnetic fields. As carried out at the Massachusetts Institute of Technology and at the Bell Telephone Laboratories, a gas-filled quartz cylinder is placed coaxially in a microwave cavity which, in turn, is held between the poles of an electromagnet and which is driven from a 50-W, variable-frequency S-band magnetron. The microwave frequency is tuned to the resonant frequency of the cavity, and the magnetic field is adjusted until the electron cyclotron frequency equals the resonant frequency of the cavity. The input power is then increased until breakdown occurs.

Alternating- and direct-current discharges are often used in devices called plasma guns and plasma jets. A plasma gun accelerates the plasma it creates to velocities exceeding 10^7 cm/sec through the use of non-uniform or time-varying magnetic fields. The term gun is usually reserved for pulse-type devices producing transient plasmas; the term jet implies a device for producing a continuous stream of plasma. Ionization in plasma produced by guns is probably between 50 and 90%, with typical temperatures between 20,000 and 100,000°K.

One of the earliest guns developed is the so-called button gun. This gun produces plasma by a high-current (1000 to 10,000 A), pulsed (0·1 to 0·5 microsecond) discharge in a vacuum between the ends of two deuterium-soaked titanium wires embedded in a resin button.

Other materials are used when it is not required that deuterium be accelerated. Plasma formed by vaporizing and ionizing the wire electrodes comes off in an expanding torus, shaped and accelerated by its own magnetic field.

Deuterium-soaked titanium washers have been stacked with alternately spaced insulators in a cylindrical configuration termed the stack or washer gun. One such gun developed at the Lawrence Radiation Laboratory has a trigger electrode in the washer hole at one end of the stack. The end washers and the trigger electrode are connected, and a discharge between the trigger electrode and the first washer is initiated from a thyratron-controlled pulse transformer, generating plasma within the hole, so that the main discharge will pass through the centre of the stack. A current of 15,000 A with a 24-μsec period is supplied from a 7·5-μF capacitor charged to 10 kV and connected through an ignitron to the end washers.

The original concept of the button gun has led to such devices as the rail gun and the crater gun used at the Stevenson Institute of Technology. This crater gun (Fig. 1) delivers to the plasma it produces up to 20% of the energy stored in the driving capacitor.

The rail gun is derived from the button gun by drawing the wires out approximately 1 metre beyond the point where they are shorted. The result is that the plasma is formed within the gun and continues drawing current as it travels down the rails to the exit. These guns are often referred to as motors, because the magnetic fields interacting with the currents in the plasma are produced by these currents, thus yielding, in effect, series motors.

A modification of the rail gun in which the wires are replaced by a coaxial electrode arrangement is known as the coaxial rail gun. An example of this gun is shown in Fig. 2, in which the button guns used to trigger the rail gun are similar to crater guns. Each button gun has a film of graphite on the ceramic separating the inner and outer electrodes. This slightly conductive path breaks down when it receives a voltage pulse. thereby vaporizing the copper. The resulting plasma burst shorts the main capacitor, vaporizing the inner rail-gun electrode.

A common way of initiating the discharge in these guns is with the plasma formed by shorting a capacitor bank with a fine wire. Another way is to admit the gas from which the plasma is to be formed by a fast-acting valve, as in the hydromagnetic gun used at the Los Alamos Scientific Laboratory. The power supply for the hydromagnetic gun is a 45-μF capacitor bank connected to the gun through ignitrons whose breakdown limits bank voltage to less than 15 kV. The ignitrons are triggered with a time delay of a few hundred microseconds, after the valve is opened, to allow the gas to spread throughout the gun barrel before applying voltage. The discharge current is a damped oscillation of roughly a 14-μsec period and a 200,000-A peak. Guns have also been built to produce 2- to 5-μsec bursts of energetic deuterium plasma, using a 1·7-μF bank at 20 kV.

An axially symmetrical but non-cylindrical discharge tube is used at the Lockheed Missiles and Space Division to study plasma acceleration. This device has a flat, solid electrode and an open ring electrode, gas being admitted at the flat electrode end. A capacitor discharge through the tube produces a current pinch at the solid electrode end which, with the aid of Joule heating, forces plasma through the ring electrode.

Although electrode plasma guns are simple in concept, electrode erosion introduces impurities into the plasma and shortens their lives. For this reason, much attention has been devoted to electrodeless guns, the operating principle of which is analogous to that of the induction motor. A puff of gas is admitted at one end of a cylindrical glass tube and is made conductive by pre-ionization. A rapidly increasing magnetic field is then created by exciting coils coaxial with the tube. This time-varying magnetic field induces currents in the ionized gas, resulting in a repulsive force to accelerate the plasma.

The pulsed accelerator under study at Litton Systems is an example of one arrangement for energizing the coils in this type of gun. Eighteen coils are sequentially excited by discharging 30-kV capacitors through a 5-ohm transmission line and a 3-element spark gap. The result is a travelling magnetic field that accelerates the plasma toroid formed at the first few coils. Before reaching the first coil, the gas is pre-ionized by a d.c. glow discharge.

Another approach to an electrodeless gun is used in the "Chalice" programme at the Stevens Institute of

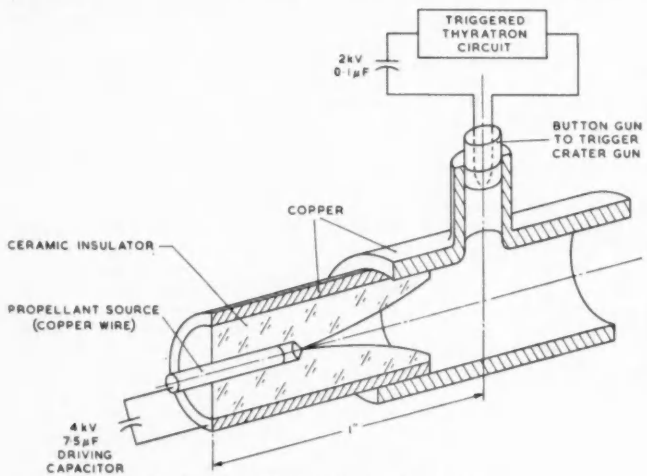


Fig. 1. Schematic arrangement of a crater gun.

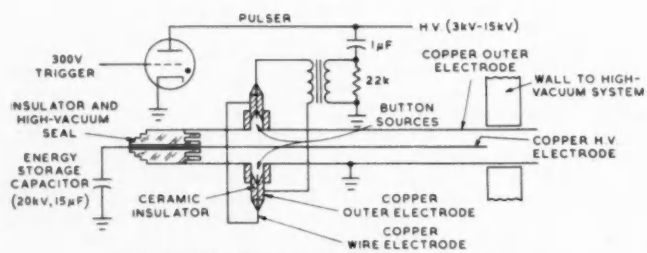


Fig. 2. Schematic arrangement of a coaxial rail gun.

Technology. The gun consists basically of a single-turn coil wound about a cylinder containing deuterium at room temperature and a pressure of 0·1 mm Hg. The gas is subjected to a high-frequency oscillating electric field created by an underdamped (ringing) capacitor discharge through the coil. Discharge of the 1-μF, 6-kV capacitor is triggered by a plasma switch fired from a thyratron pulser. This step yields a plasma temperature of the order of 10,000°K. A 50,000-joule, 50-kV bank with a ringing period of 2 μsec is then discharged through the coil. The electric field induced in the plasma by the rapidly increasing current produces azimuthal currents in the plasma, giving rise to an axial magnetic field between the coil and the plasma current sheath, and driving the plasma towards the central axis so rapidly that it is first shock-heated and then compressed adiabatically, forming a hot thread along the axis. The coil is shaped so that the axial magnetic field strength is strongest at the coil edges, thus providing a magnetic-mirror configuration. However, one mirror is made more resistive than the other, so that the magnetic field is opened and the plasma accelerates out of the gun.

To obtain high-speed plasmas, it is necessary to minimize inductance, so as to obtain a fast-rising magnetic field. For example, spark gaps and insulators being developed for the electrodeless gun at the Institute of Physics in Uppsala, Sweden, are expected to increase discharge current to 750,000 A and to reduce rise time to 0·28 μsec with a 4·4-μF, 30-kV capacitor bank. In this gun, the pulsed capacitor discharge excites a flat, single-turn primary coil behind a thin porcelain disc forming one end of a cylindrical discharge tube. A solenoid surrounding the tube gives a longitudinal field up to 5000 gauss.

Propagation of high-velocity shock waves down the constant-area channel of a shock tube is another method of producing hot, highly ionized plasma. This method is also advantageous in that the properties of the plasma formed behind the shock front are uniform and are readily determinable.

One method of producing such shocks is with the bursting-diaphragm type of tube. Here, a low- and a high-pressure volume are separated by a thin diaphragm which, when punctured, allows a compression wave to move from the high to the low-pressure region and to steepen into a planar shock front. Chemically driven diaphragm shock tubes yield Mach numbers up to around 20; for Mach numbers of the order of a few hundred, there are various electrically driven gas-discharge shock tubes such as the T-tube.

The T-tube consists essentially of a pair of electrodes in the arms of a glass T filled with gas. A capacitor bank is discharged across the electrodes, causing an increase in gas pressure and the formation of a shock wave. The return lead of the circuit is oriented so that the magnetic field associated with the current surge is perpendicular to the current path, resulting in acceleration up the expansion leg. In the T-tube, the plasma driving force rapidly diminishes with increasing distance from the localized magnetic fields of the accelerator. One solution is to add a time-rising axial magnetic field along the expansion leg, another to use different geometries.

An electrically driven conical shock tube used at the Space Technology Laboratories consists of a tapered glass tube with a solid nickel electrode at the small end and a large ring electrode at the other. Deuterium is fed through a port in the ring electrode, and a discharge is produced by transferring the energy from a 6·2-μF, 24-kV capacitor bank through a triggered spark gap.

Another type of shock tube, which is actually similar to the hydromagnetic plasma gun, is the magnetic annular shock tube. In this tube, the gas is confined in the annular region between two concentric cylinders whose radii are large, compared with their annular spacing. Radial currents created by discharging a capacitor bank across two cylindrical tungsten electrodes give rise to an azimuthal magnetic field of 10,000 to 20,000 gauss, which is the driving force for high-velocity shock waves.

Two types of bias field have been used ahead of the shock front to provide uniform gas breakdown at the electrodes and containment during acceleration. In one type, a solenoid around the tube provides an axial magnetic field, and the gas is pre-ionized by a 10-A, 1-Mcs discharge. The second type is an azimuthal magnetic field obtained by discharging a capacitor bank through a conductor at the axis of the tube, combined with the axial field produced by two solenoids, one of which is inside the annular region and the other outside. Pre-ionization in this case is with an electrodeless discharge in the vicinity of the electrodes. Shock velocities above 5×10^7 cm/sec have been produced when using a sufficiently strong azimuthal bias field.

Direct-current discharges involving the generation of plasma include sparks, glows, and arcs. In a spark discharge, ionization is usually dense along a narrow path, while arcs and glows produce considerable volumes of plasma. A glow discharge is characterized by a potential drop across the discharge of the order of several hundred volts and a current of a few milliamperes. The current in an arc discharge is in the 1- to 1000-A range, while the voltages are lower than in the glow discharge (usually about 30 to 90 V).

The electric arc discharge has found considerable use as the energizing source in devices called plasma-jet generators, or simply plasma jets. Fundamentally, an arc discharge consists of three regions, i.e., the arc column, and the cathode and anode fall spaces. The fall spaces extend only a few tenths of a millimetre from the electrode surfaces and are regions of high potential gradient and energy density, as compared with the arc column itself. In a normal arc discharge, the anode voltage is approximately equal to the ionization potential of the gas.

In the ordinary low-intensity open arc used to treat materials, some 80% of the input energy is dissipated in the arc column, leaving as radiant energy. Column temperature is around 5000°K. To obtain greater energy concentration and temperature requires increasing the current density until the arc is converted to one where the current density dissipated on the electrode surface is greater than can be removed by radiation and conduction alone.

One way to obtain such an increase in current density is to confine all or part of the arc column in a chamber or nozzle, into which relatively cold fluid flows under pressure. Cooling the periphery of the column lowers thermal ionization and hence the conductivity. This action constricts the conduction path and crowds the arc current closer to the centre of the plasma, thereby increasing current density and temperature.

Essentially, most fluid-stabilized plasma-jet generators have a chamber closed at one end by a solid electrode; at the other end is a pierced-plate electrode through which the jet issues. The arc may be struck by touching the electrodes, connecting with a wire, or by R.F. pulsing. The fluid (water or gas) can be introduced

axially or tangentially. Tangential introduction produces a vortex along the axis of the discharge and is termed a vortex-flow-stabilized or Gerdien arc. For additional arc constriction, the chamber or nozzle may be surrounded with a solenoid.

Some arc generators are constructed so that the diffusion of heat from the plasma column sets up a gradient that confines the column. These are known as wall-stabilized arcs. While operation can be smooth, increased heat load generally lowers efficiency.

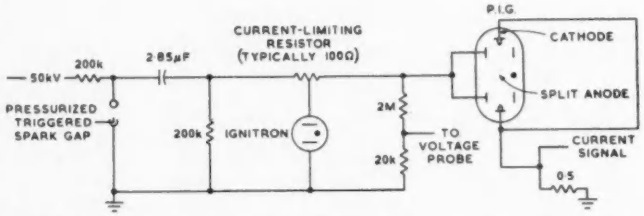


Fig. 3. Circuit arrangement of a split-anode Philips ionization- gauge discharge tube.

An example of a magnetically confined arc is provided by the hollow-cathode arc used at M.I.T. The hollow-cathode arc operates with a refractory metal cathode through which a continuous flow of argon is maintained. A magnetic induction of a few hundred gauss confines the arc to a column which has approximately the same diameter as the cathode and extends from the cathode to the anode. The total power input is of the order of 1 to 2 kW. Plasma, with a density in the range of 10^{13} to 10^{14} electrons/cm^3 and approximately 50% ionized, is produced in a vacuum. Cathode sputtering is negligible, and the arc has been run continuously for 8 to 10 hr with a tantalum cathode. Also under study are annular-type jets, in which the arc strikes radially from an inner to an outer electrode and is rapidly rotated with a magneticfield.

A second method of operating a stable arc at higher power and temperature than for a low-intensity arc is to increase the current density at the anode face of a low-intensity arc of the proper configuration until the energy input to the anode surface is great enough to vaporize the electrode material. When this occurs, a jet of electrode plasma issues from the surface. The current/voltage characteristic in this so-called high-intensity arc reverses from the customary negative to positive. The anode fall space dissipates 60 to 70% of the total arc power. Because of this efficient transfer of energy to the anode, vaporization occurs rapidly enough for energy to be carried away at the rate required for stable operation, and hence the arc is considered self-stabilized.

The visible tail flame of the high-intensity arc has a volume several times that of the jet from a fluid-stabilized arc at equivalent power levels. This makes the high-intensity arc useful for such applications as re-entry simulation, while the steeper temperature gradient makes the fluid-stabilized arc useful for such applications as cutting materials.

Although anode energy density in the high-intensity arc can exceed 100 kW/cm^3, electrode erosion and limitation of plasma composition to the vaporized anode material limits the practicability of the solid-anode, high-intensity arc. For this reason, researchers at the Vitro Laboratories have developed a fluid-transpiration arc. This arc uses a porous anode through which liquids or gases can be injected to form a plasma. Vaporization of the anode is not required to maintain the arc in the high-intensity mode, and the outflowing gas from the anode cools the surface to a temperature low enough to prevent erosion. Using argon and porous graphite electrodes, more than 75% of the 50-kW arc input power is delivered to the gas; electrode erosion rates of 10^{-5} gm/sec have been observed.

Somewhat similar to the d.c. arc plasma is the induction plasma generated in the M.I.T. Lincoln Laboratories electrodeless plasma torch, in which plasma is generated at atmospheric pressure by using inductive coupling at 4 Mcs. The torch uses vortex stabilization and produces a plasma whose peak temperature ranges from 14,000 to 19,000°K. The total energy transferred to the plasma ranges from about 52 to 57% of the input power.

For large-scale facilities where electrode power in the megawatt range is required, a.c. arcs are being used. The Missile and Space Vehicle Department of General Electric has developed a three-phase, 2·5-MW air arc that can be operated with either carbon or copper electrodes. With carbon electrodes the maximum power input is 14·5 MW, and approximately 2·5 MW is added to the test gas. With water-cooled copper electrodes, approximately 1·5 MW of air power at electrode contamination levels of less than 1% is produced. The maximum power input is 5 MW.

Westinghouse has developed a magnetically confined diffuse arc for d.c. or single-phase a.c. operation. The arc is drawn across the gap between two toroidal electrodes of 12 in. diameter and is then rotated around the gap at high speed by a d.c. magnetic field. Approximately 55% of inputs up to 15 MW is transferred to the plasma, whose temperature ranges up to about 12,000 °K. A three-phase arc now under investigation would use four electrodes and would possibly run at 50 MW.

A frequently used method for continuously producing plasma makes use of the Penning-type discharge (also called a Philips ionization gauge or P.I.G. discharge). Basically, the device consists of two grounded cylindrical cathodes on a common axis with a cylindrical anode, positive with respect to ground, between them. An axial magnetic field produced by an external solenoid forces the emitted electrons to oscillate between the cathodes and restrains them from collecting on the anode. Interaction of the trapped electrons with a low-pressure gas results in the formation of a plasma.

Electrostatic potential gradients existing in a P.I.G. discharge over dimensions which are large compared with the Debye length can be utilized to eject the positive ions in a directed beam, neutralized by escaping electrons.

Split-anode P.I.G. discharge tubes have been constructed at the General Electric Research Laboratory for producing a highly ionized, clean deuterium plasma in a mirror-geometry magnetic field. Microwave measurements have indicated greater than 80% ionization in a hydrogen plasma. The circuit is shown in Fig. 3.

Plasma beams have also been generated with pool-type mercury discharge tubes. By locating a field of thermionically emitted electrons behind an ion acceleration mesh, researchers at Convair have obtained beams 3·6 cm in diameter with densities of 2×10^8 ions/cm^3 of 100-eV Hg^+ ions 15 cm from the extractor.

Plasma can also be produced by the interaction of an

(*Concluded on page 125*)

SPIROLOX

THEY SPIRAL ON

THEY SPIRAL IN THEN THEY LOCK

SPRING-STEEL **RETAINING RINGS**

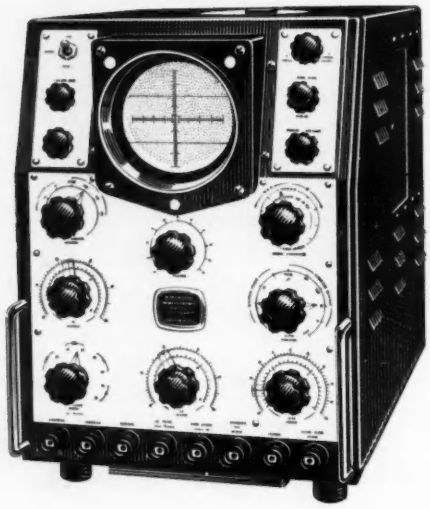
Spirolox give quick, positive locking without special tools. Symmetrical design ensures all round locking pressure inwards or outwards and a perfect balance ideal for high-speed rotation.

Spirolox are non-tangling in storage and are made for strength in three or more turns of high grade flat spring steel. There is a Spirolox size to suit every application.

WELLWORTHY
The Choice of the Expert

WELLWORTHY LIMITED
LYMINGTON HANTS
Phone Lymington 2231

Æ AN ASSOCIATED ENGINEERING LTD COMPANY



A WIDE RANGE OF APPLICATIONS

Cossor Oscilloscope Model 1035 Mk. III is a general purpose instrument designed to cover the ever-increasing demands of modern industry. A few of the fields in which this very popular oscilloscope is used are given below.

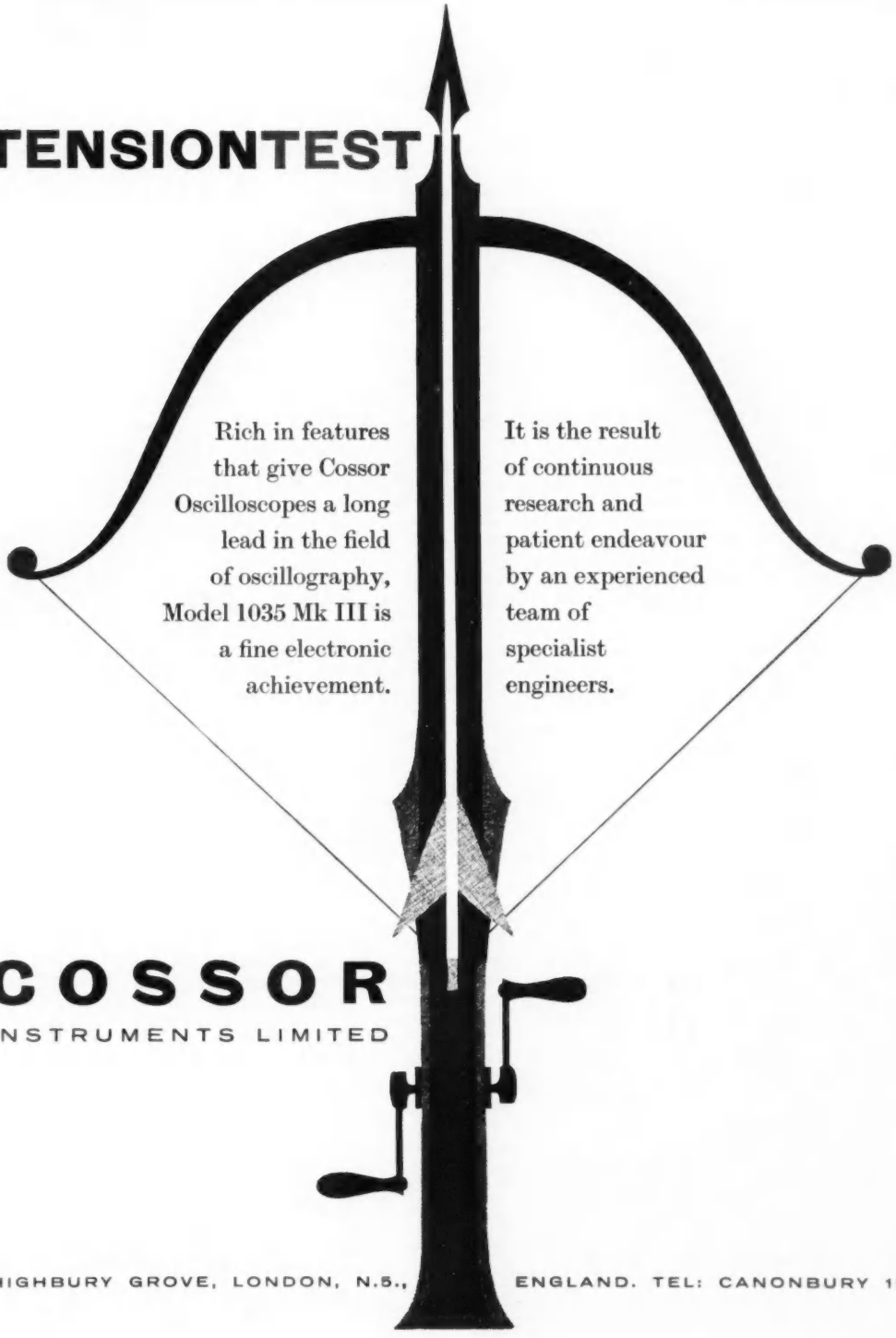
Aircraft	**Film**
Chemical	**Medical**
Communications	**Radio**
Computer	**Television**

OSCILLOSCOPE MODEL 1035 Mk. III

Cossor manufacture the most extensive range of measuring oscilloscopes available commercially. Please write for details of instrumentation comprising over 50 different aids to industry.

COSSOR INSTRUMENTS LIMITED, COSSOR HOUSE,

TENSIONTEST



Rich in features that give Cossor Oscilloscopes a long lead in the field of oscillography, Model 1035 Mk III is a fine electronic achievement.

It is the result of continuous research and patient endeavour by an experienced team of specialist engineers.

COSSOR

INSTRUMENTS LIMITED

HIGHBURY GROVE, LONDON, N.5., ENGLAND. TEL: CANONBURY 1234

12

Factory Heating—2

It is impossible in this Data Sheet to describe in detail every type of electric heater on the market, but a representative selection is dealt with below. Each type of building presents its own problem, and the best plan is to seek advice from your local Electricity Board, who will always be pleased to help.

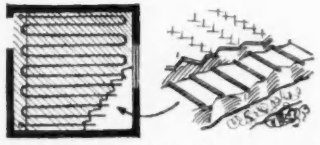
'OFF PEAK' ELECTRIC HEATING

Because the 'off peak' load makes use of generating and distributing equipment when it would otherwise be idle or underloaded, the Electricity Boards offer cheap 'off peak' tariffs. Three types of 'off peak' heating systems are available, namely:

(a) Hot water storage heating: This consists of a conventional hot water radiator or panel heating system through which hot water from a large storage vessel is circulated. The water in the storage vessel is heated electrically during the 'off peak', low-tariff hours and is circulated when required through the radiators or panels.

(b) Block storage heaters: These heaters consist essentially of a number of firebrick blocks which are heated up during the 'off peak' hours by means of suitable electric heating elements. The storage heaters are clad with a layer of suitable heat-insulating material and are housed in a sheet metal casing, the design being such that the stored heat is gradually dissipated throughout the day by means of radiation and convection. These heaters can easily be installed in existing buildings.

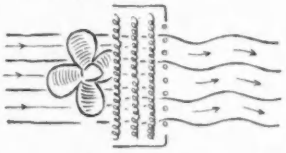
(c) Floor warming: In an 'off peak' floor warming installation, electric heating cables or ducts housing withdrawable cables are embedded in the concrete floor of the building. The cables are switched on and the floor is heated up during the 'off peak' hours, and the mass of concrete and screed of the finished floor has sufficient thermal storage capacity to heat the building during the period when current is not available. This method is only applicable to new buildings.



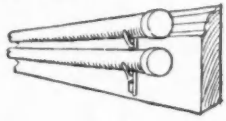
Plan view of room Isometric view of heating cable

DIRECT ELECTRIC HEATING

(a) Unit heaters: These consist of a bank of electric heating elements fixed in a casing on which is mounted a fan which draws or blows air over the heating elements and discharges it in the required direction. Such units are mounted on the walls or stanchions or hung from the roof members in appropriate positions throughout the works.



(b) Infra-red heaters: These consist of heating elements usually of the sheathed metal or silica tube type mounted in a polished reflector. They operate at temperatures from 700 to 900°C, and give off the greater part of their heat output by radiation. They are mounted overhead and are particularly useful for providing local areas of comfort in spaces not otherwise heated.

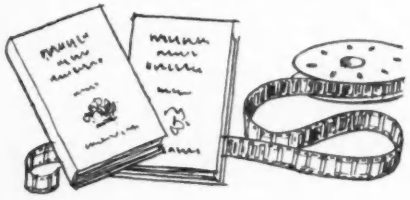


(c) Tubular heaters: These take the form of tubes approximately 2" in diameter containing an electric heating element and are available in lengths from 2 to 17 ft. The normal loading is 60 watts per foot run and the surface temperature is from 180 to 200°F. They are usually placed round the walls at skirting level, but also can be used at high level in order to prevent downdraughts.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on the industrial and commercial uses of electricity and reprints of articles and papers are available.

E.D.A. have available on free loan in the U.K. a series of films on the industrial uses of electricity. Film and Book catalogues and Publications List sent on request.

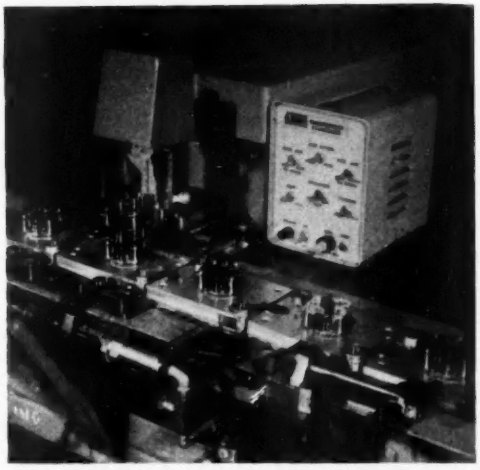


CUT HERE

British Industrial Developments

Low-Cost Automation Equipment

Described as the first low-cost industrial robot and designed to work on any assembly line under the command of its own electronic brain, the "TransfeRobot 200" is a versatile device which enables automation on the assembly line to be brought within reach of small, as well as large, manufacturers. As announced by U.S. Industries Inc. (Great Britain) Ltd., of London, W.1, the device, which has for some time been in production in the U.S.A., is capable of performing a very large number of tasks in assembly and related operations and, as distinct from previous products in this field, which are special-purpose machines, it is the first general-purpose automation machine to be made available to manufacturers as a standard item of equipment.



The versatility of the "TransfeRobot 200" stems from the fact that it can be programmed to perform a large variety of operations merely by changing a number of accessories. Essentially, the machine consists of an arm which can be retracted or extended, as required, and an actuator which can be fitted with numerous types of fingers or jaws, all under the control of a self-contained electronic brain. The fingers or jaws are used to seize, move, position, and relinquish the workpiece being handled. With the incorporation of an accessory swivel, the machine acquires a "wrist", enabling it to perform virtually any required set of motions within the limit of its reach. As commanded by the electronic control unit, the machine not only performs its own tasks, but also can order other machines (including other "TransfeRobot" machines) to act as well. As a result, it is in constant communication with the rest of the production line. Also, if something goes wrong with the work programme, the machine stops and flashing lights or buzzers indicate that the error should be located and corrected. Programming is stated to be extremely simple, so much so that the average foreman, machinist, or set-up man should be able to learn to programme the machine within one hour.

During a recent demonstration in London, Mr. E. F. Shelley, creator of the "TransfeRobot" concept and vice-president of U.S. Industries Inc., who manufacture the machine in the U.S.A., stated that the equipment is already being used by a number of large American companies in the manufacture of such varied products as business machines, razors, clocks, and automotive and electrical equipment. For example, at the typewriter plant of the Underwood Corporation, the machine is used to pick up, transfer, and place small typewriter components into a close-fitting nest for an automatic machining operation. In another application involving the manufacture of an automobile steering assembly, the machine feeds partially fabricated parts to a trimming press, orders the press to cut off excess material, and ensures that the finished parts are properly discharged from the press. The illustration shows the "TransfeRobot" and its electronic control equipment in use at the Westclox plant in LaSalle, Ill., where it is being used to oil complete clock assemblies as they pass on a conveyor belt, eight precision bearings being simultaneously oiled in one second.

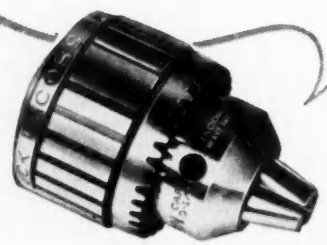
Xerographic Output Printer for Computers

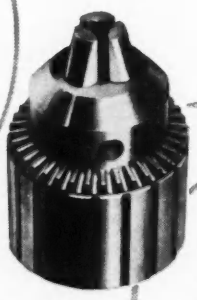
Developed and manufactured by Rank Precision Industries Ltd., of London, W.1, the "Xeronic" is stated to be the fastest and most versatile business-computer output printer in the world. The machine is a complete departure from conventional computer output printing methods, inasmuch as there are no high-speed mechanical parts, a combination of xerography and an electronic method of character generation being used exclusively.

The machine can print information from computers onto plain paper at a rate of 4700 characters per sec,

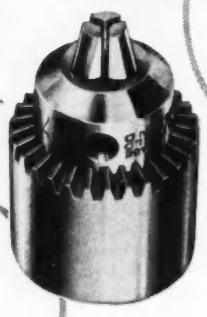
INSIST ON GENUINE Jacobs CHUCKS

" I'm not talking out of the back of my head "





" I quite believe you. A true chuck runs true because it is a true Jacobs chuck made by Jacobs—the best known name in chucks "



" Your dealer can supply genuine Jacobs chucks in all sizes for light, medium or heavy duty "

THE JACOBS MANUFACTURING COMPANY LIMITED, ARCHER RD., SHEFFIELD, 8

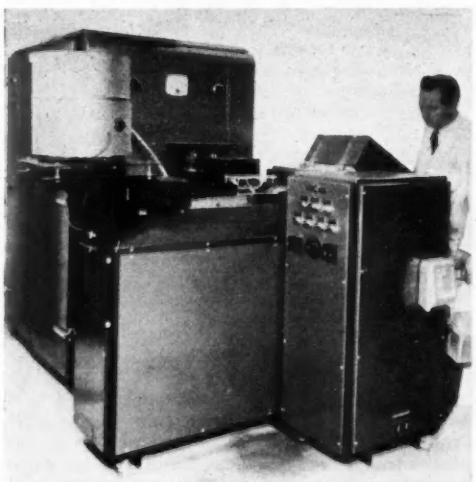
JC/3

equivalent to reproducing the entire contents of the Bible in about 15 min. Simultaneously, it prints its own forms to contain the information. At present, a selection of four different designs of form is available, but development is in progress of a new machine which will be able to select from no less than 32 forms. The signals from the computer are written by a beam of electrons onto the screen of a cathode-ray tube. This visual image is then copied by xerography onto a continuously moving roll of paper. A comprehensive automatic system of detecting and indicating printing errors is incorporated in the machine.

The first production model of the "Xeronic" printer has been completed and will be used with an "Emidec 2400" electronic computer to be delivered this year to the Ministry of Pensions and National Insurance in Newcastle. Of other machines to be delivered this year, one will go to Ferranti for use with one of their "Orion" computers at the company's data-processing centre; a second machine will be delivered to A.E.I., Ltd., to work with an "AEI 1010" computer in the R.A.F. Central Accounting Unit at Hendon, while a third machine will go to the Commercial Union Assurance Co. Ltd., for use with an English Electric "KDP 10" computer at the new data-processing centre in Exeter.

Hopper-Fed Induction-Hardening Machine for Screws or Pins

Although primarily designed for hardening the tips of rocker screws used in the motor-car industry, a new induction-hardening machine supplied by Induction Heating Equipment Ltd., of Hersham, Walton-on-Thames, Surrey, and recently installed in the factory of a leading British car manufacturer, is also suitable for hardening many types of screws and pins, particularly where large quantities are involved.



The screws or pins to be hardened are poured into a hopper, which is a vibratory feeder that forces the components up an internal flight and a through a gate mechanism to ensure that they are the correct way round for feeding into the machine. The screws or pins are fed into nests mounted on a stainless-steel endless belt, which carries them through a "skate-type" high-frequency coil fed from a 400-kcs generator via a suitable transformer. After heating the tips to hardening temperature, the screws then pass through a quench-tunnel, finally falling into a wire basket at the end of the line. The components are automatically fed one at a time through a shutter mechanism, any over-feed from the feeder being controlled by an electromagnetic stop mechanism. The standard rate of processing is 1500 pieces per hour.

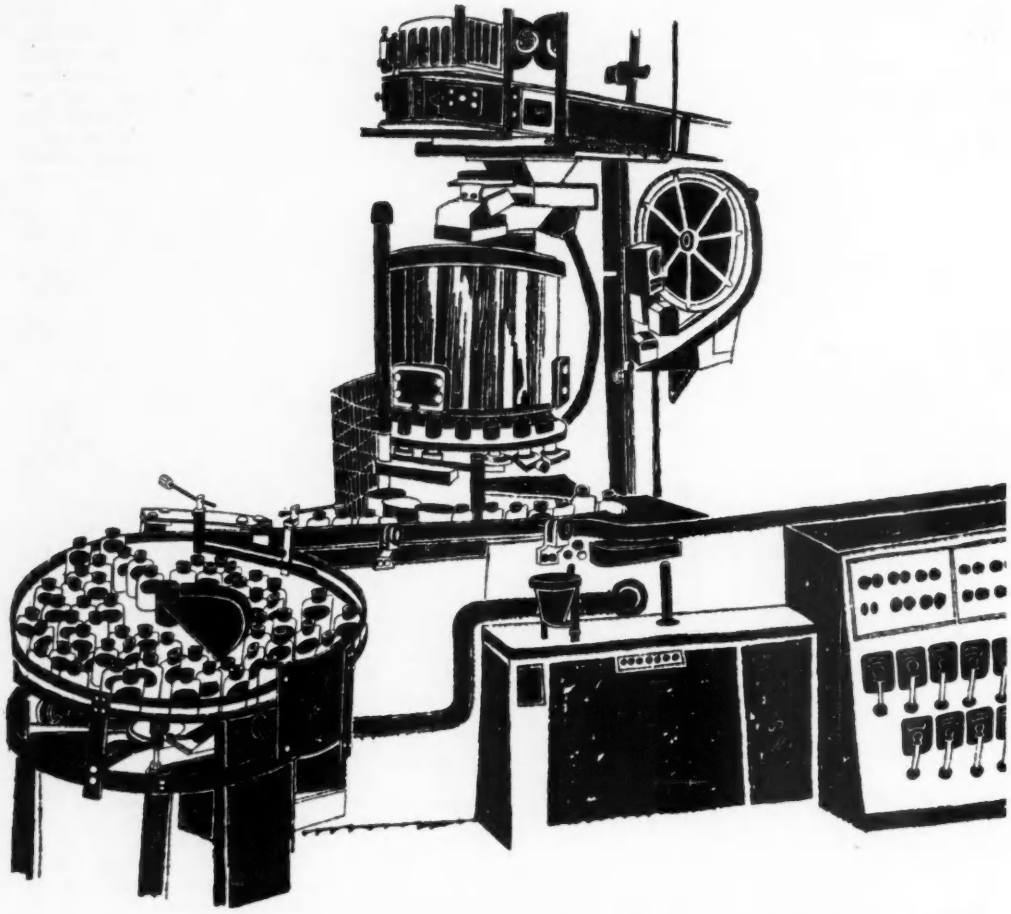
Non-Aqueous Phosphating Process

A new non-aqueous phosphating process, designated "Kephos", has been developed by the Paints Division of Imperial Chemical Industries Ltd., of London, S.W.1, and is stated to dispense with rinsing and tank heating, to form no sludge in the processing tank, and to produce a sealed phosphate coating which enhances paint adhesion and resistance to rust creep in the same way as conventionally produced zinc or iron phosphate coatings.

The process incorporates a sealer which is sufficiently corrosion-resistant to protect work during transport or during temporary exterior storage for up to one week, or indoor storage up to six months. Under normal production conditions, work can be welded through the film produced, enabling items to be treated before fabrication, so that shrouded areas such as interior box sections receive some protection. The process is not confined to dipping, but can be applied by brush, roller, spray, or flow-coating, the most suitable method depending entirely on the characteristics and number of the articles to be treated. The process can also be used to supplement existing phosphating facilities when items are too large for the existing plant or when an abnormal volume of work requires processing. It is true that, for regular work, the process has a higher chemical cost, but this is offset by the compactness and simplicity of plant requirements and the saving in heating and maintenance costs, particularly in the case of manufacturers with a small-volume or high-quality production. The ideal method of using the process is to degrease all work on arrival and to apply the phosphate coating before the work is put into store; in this way, the work is simultaneously protected and phosphated during storage and subsequent assembly, requiring only the removal of surface dirt to prepare it for painting.

Low-Cost Automatic Portable Spot-Welding Equipment

Although designed to retail at a comparatively low cost, the "Bren Weld" equipment, manufactured in the U.S.A. by the Bren Weld Corporation, of Brooklyn, N.Y., and marketed in the U.K. by E. P. Barrus (Concessionaires) Ltd., of London, W.3, is suitable for a wide range of applications, especially (but by no means exclusively) in connection with sheet-metal construction work. Essentially, the "Bren Weld" is a spot-welder, but operates on the arc-weld principle. In other words, it uses a coated electrode which cuts a hole through the metals to be welded and simultaneously fills it in, so that the finished weld resembles a rivet. A major advantage over conventional spot-welding equipment is the portability of the equipment, which consists of a gun which weighs only 2½ lb, connected by a flexible lead to a transformer, the total weight of the gun and transformer combined being only 43½ lb. Moreover, the equipment is used from one side of the workpiece and will not only produce sound welds between sheets of up to 12 s.w.g.,



THE MONEY THAT MANAGEMENTS SAVE THROUGH MOBIL ECONOMY SERVICE

More than £3,000 saved in a year at Reckitt & Sons Ltd

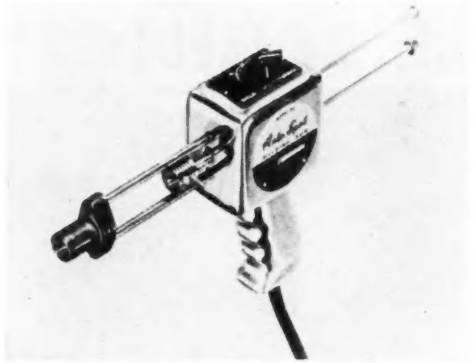
RECKITT AND SONS LTD of Hull, asked Mobil to suggest improvements in the maintenance and lubrication systems at four of their factories. Mobil advised using a card index system to ensure regular and correct lubrication, reducing the number of oils stocked, reclamation of used oil, and several other schemes of preventive maintenance and purchasing rationalisation.

In one year, after applying Mobil's recommendations, Reckitt made a direct saving of over £3,000. A further immediate saving of over £900 is probable.

World-wide experience of industrial lubrication has been built up by the Mobil Organisation over 90 years. The Reckitt case is one of hundreds in which the recommendations of the Mobil Economy Service have successfully cut lubrication and maintenance costs.

Specialist knowledge methodically applied is the value of the Mobil Economy Service. The total lubrication requirements of a business and the minimum number of lubricants in the smallest quantities it needs must be assessed. And everyone concerned must know how to achieve the best lubrication results with the greatest economy of labour. These are tasks undertaken by the Mobil Economy Service —and the big savings resulting from its recommendations are a measure of its success.

Mobil
ECONOMY SERVICE



but also will weld a sheet of 12 s.w.g. or less to steel sections of unlimited thickness.

The welding gun, designated Model 90, is shown in the illustration and is fully automatic in terms of feed, time control, and resetting. A time-control dial on the gun predetermines the forward travel of the electrode and this, in turn, limits the time cycle of the welding current. No resetting is necessary between welds—a point of special importance in production work. The heat is concentrated in a very small area by means of a nose-guide shield, so that there is very little risk of distortion caused by metal buckling from the heat. The versatility of the gun can be further extended by using alternative nose shields, i.e., concave shields for external angles, convex shields for internal angles, and lap shields, each of which is available in three sizes.

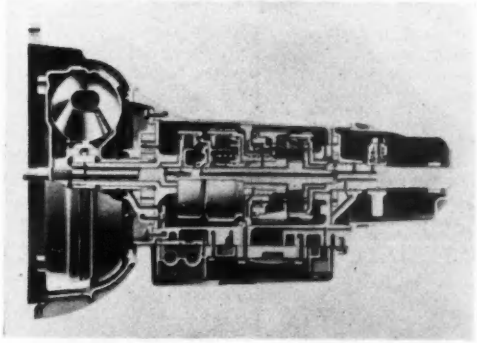
The gun is used in conjunction with a special power pack, measuring only $8\frac{1}{2} \times 12 \times 12\frac{1}{2}$ in. overall, and incorporating a transformer whose windings have been double glass-insulated, varnish-impregnated, and baked. The power pack has a range of five heat settings, adjustable in conjunction with the time control for varying gauges of metal. The pack can also be used for standard arc-welding on a 20% duty cycle, and for this purpose is fitted with a thermal overload trip-switch.

Fully Automatic Transmission for Medium-Size Cars

Designed to complement their well-known automatic transmissions for larger cars, the new Model 35 fully automatic transmission announced by Borg-Warner Ltd., of Letchworth, Herts., has been specifically designed for use with medium-size British and Continental cars, and is being initially fitted to a number of British makes in the $1\frac{1}{2}$-litre range. The weight penalty usually associated with automatic transmissions has been entirely eliminated by the extensive use of light alloys, and the new transmission is stated to be unique, insofar as automatic transmissions for medium-price family cars are concerned, to include in its specification a "park" position on the selector, as well as the ability in an emergency, e.g., a flat battery, to permit starting the engine through the rear wheels.

The transmission essentially comprises two main components, i.e., a hydraulic torque-converter coupling, which replaces the conventional flywheel and clutch, and a hydraulically operated automatic gearbox incorporating a planetary gear set providing three forward ratios, i.e., 2·39 : 1, 1·45 : 1, and 1 : 1, and a reverse ratio of 2·09 : 1. These different mechanical ratios are obtained by the engagement of hydraulically operated multi-disc clutches and brake bands. The torque converter is available in diameters of $9\frac{1}{2}$ and 11 in., the choice being determined by the torque-curve characteristics of the engine. Both sizes are of the single-phase, three-element type, comprising an impeller connected to the engine crankshaft, a turbine connected to the input shaft of the gearbox, and a stator mounted on a sprag-type one-way clutch supported on a fixed hub projecting from the gearbox case.

The torque-converter coupling and the automatic gearbox share a common fluid supply, the hydraulic and lubrication requirements of the transmission being provided by two pumps located in the gearbox. One pump is driven by the engine, while the other is driven by the output shaft, thus enabling the engine to be push- or tow-started in an emergency. The hydraulic system also comprises a governor rotated by the output shaft to sense vehicle speed, and an assembly of valve bodies connected mechanically both to the selector and the accelerator and connected hydraulically to the governor. The system is responsive to manual selection and also to vehicle speed and engine torque. As a result, it produces appropriate clutch and servo operation for effecting fully automatic or manual up and down gear-shifts.



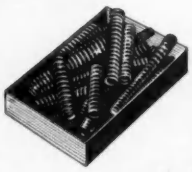
The transmission system provides a means of obtaining a smooth application of engine power to the driving wheels and additional torque multiplication to the first and second gears of the gearbox. The converter also provides extreme low-speed flexibility when the gearbox is in third gear and, because of its ability to multiply engine torque, provides good acceleration from very low road speeds, without having to change to a lower gear. Torque multiplication from the converter is infinitely variable between the ratios of 2 : 1 and 1 : 1. The speed range during which torque multiplication can be achieved is also variable, depending on the accelerator position.

Elecric Motors with Reduced Frame Sizes

A new range of totally enclosed, fan-cooled, cage-rotor motors, with ratings from 0·5 to 50 hp, has been developed by Lancashire Dynamo & Crypto, a member of the Metal Industries Group, and is now in production at their works in Willesden, London, N.W.10. The new range, designated "Crypto-D", stems from the possibility of Britain joining the Common Market and the consequent need to offer motors having outputs at least equal to those produced to the German Standard Specification DIN 42673. The result is a range of motors

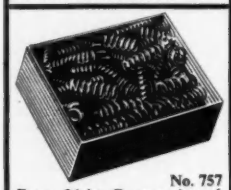
EXPERIMENTAL SPRINGS?

No. 1200
Three dozen Assorted Light Expansion Springs, suitable for carburettor control, etc. **15/-.**



No. 760
Three dozen Assorted Light Compression Springs. 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. **7/6.**

No. 98A
Three dozen Assorted 1" to 4" long, ½" to ¾" diam., 19G to 15G. **6/6.**



No. 757
Extra Light Compression, 1 gross Assorted, ¼" to ⅜" diam., ½" to 2¼" long, 27 to 19 S.W.G. **18/-.**

No. 753
Three dozen Assorted Light Expansion ½" to 1" diam., 2" to 6" long, 22 to 18 S.W.G. **12/-.**

No. 758
Fine Expansion Springs. 1 gross Assorted ½" to ¾" diam., ½" to 2" long, 27 to 20 S.W.G. **18/-.**

That spring you want . . . in a hurry . . . where is it? Pick what you want, when you want it, from TERRY'S BOXES OF ASSORTED SPRINGS —our fine range of small boxed assortments of experimental springs. We can show you only a few from the range here. Send a postcard for our full list—and if ever you're stuck with a spring problem send it along to our Research Department—they'll gladly help you out.

Have you a Presswork problem?

If so, the help of our Design Staff is yours for the asking.

TERRY'S *for SPRINGS*

Really interested in Springs? "Spring Design and Calculations" 10th Edition tells all—post free **12/6.**

Cut Production Costs with Terry's Wire CIRCLIPS. We can supply immediately from stock — from ¼" to ⅝".

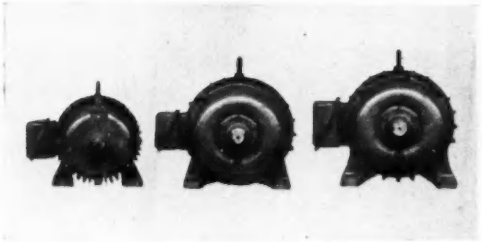
Looking for good Hose Clips? Send for a Sample of Terry's Security Worm Drive Hose Clip and price list.

HERBERT TERRY & SONS LTD.
Redditch, Worcs.

(Makers of Quality Springs, Wireforms and Presswork for over 100 years.) HT3IC

which are stated to be the first of their kind to be offered by a British manufacturer to world markets, and which enable the company to compete with European manufacturers.

The new motors are dimensionally to BS 2960 Pt. 2 (1960), and also comply with American standards, Continental standards, and international recommendations. The illustration shows the relative sizes of three 10-hp, 1500-rpm 4-pole motors. The largest is to BS 2083, the second largest is to BS 2960 Pt. 2, which supersedes BS 2083, while the smallest (the "Crypto-D") is to DIN 42673. In this connection, it should be noted that the "Crypto-D" motors have outputs equal to those of DIN specifications and, in some cases, even better outputs are obtainable. Their outputs are considerably in excess of those quoted in BS 2960 Pt. 2, and these higher outputs are available with performance to BS 2613, Class E insulation, 65°C temperature rise (40°C maximum ambient temperature), continuous maximum rating.



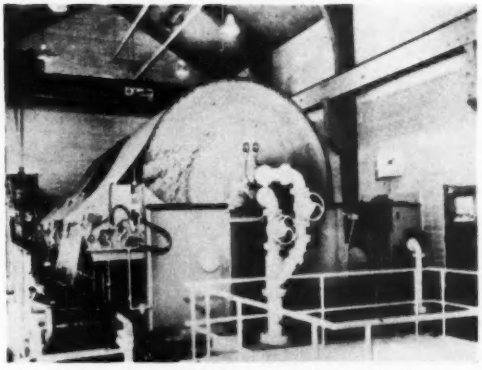
The motors, which can be either of the horizontal foot-mounted or flange-fixing types, are suitable in every way for all applications and are especially advantageous where the use of smaller motors is essential and for duties where reduced rotor inertia is particularly important. The stud-type terminals, which have been designed with adequate clearances between phases and to earth, are readily accessible and are housed in a spacious terminal box with a cable inlet adjustable through angles of 90 deg. On all sizes, the ball bearings used are of the standard medium metric type, preloaded for optimum performance, the bearings being precharged with high-grade lithium-base grease. Lubricating nipples are provided, though relubrication is not necessary, except after long intervals. The ventilating fans are of aero-dynamic design, providing maximum cooling with minimum turbulence and noise. The rotors are dynamically balanced, ensuring quiet running and freedom from vibration, while the stator windings are well braced, are insulated with first-grade materials, and are fully impregnated. Special requirements for protection against weather and against corrosive and dust-laden atmospheres can be met. For use with gearboxes, etc., oils seals can be provided.

Continuous-Discharge Rotary Vacuum Filters

Suitable for use in a wide range of applications, including the chemical, petroleum, mining, iron and steel, and food industries, as well as in sewage plants and in general processing fields, the "ElmcoBelt" rotary vacuum filter, developed by the Elmco Corporation of America, is now being manufactured in Gateshead by Elmco (Great Britain) Ltd. The oustanding feature of these filters, which are stated to offer increased efficiency and reduced operating costs, is the method used for removing the filter belt from, and returning it to, the drum in the course of each revolution, thus resulting in an improved discharge of the filter cake. The use of a scraper blade or an air blow is dispensed with, and the belt is washed before being returned to the drum; thus, a clean filter medium is always in use, giving sustained high filtration efficiency and drastically reducing down-time for cleaning the belt.

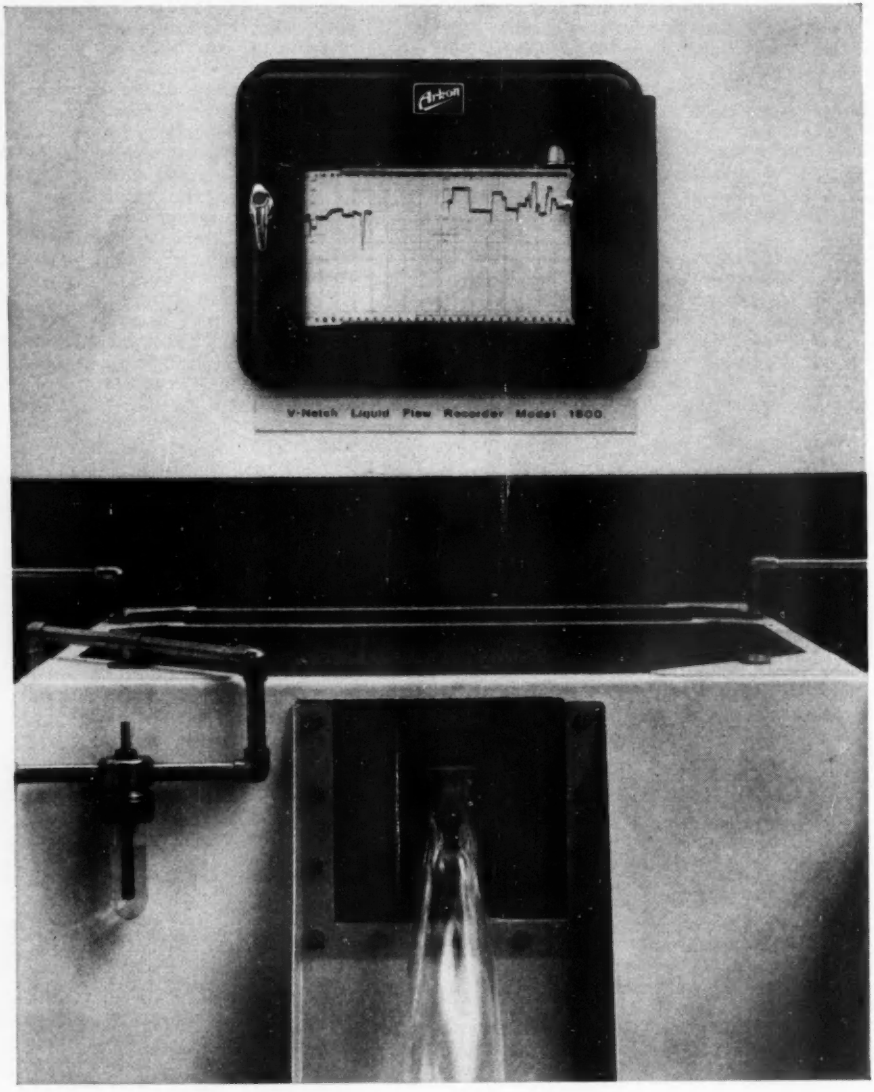
Unlike conventional drum filters, it is not necessary to install a larger unit than is strictly necessary to overcome progressive blinding of the filter medium. The absence of a scraper blade reduces wear on the filter belt and increases its life. When belt changing is necessary, a zipper joint in the belt enables this to be done in less than half an hour, as compared with the 4 to 8 hrs taken to change a conventional belt. The filters are manufactured in standard sizes ranging from 18-in. diameter by 12-in. face, to 14-ft diameter by 16-ft face. The smaller models are used in laboratories and pilot plants, while the larger types cater for almost any industrial filtration requirement. The freedom of these filters from blinding of the medium enables them to handle difficult slurries which cannot otherwise be filtered continuously.

In each filter cycle, the belt is removed from the drum and is passed round a small-diameter discharge roller. The sharp change in radius causes the cake to break sharply away from the belt, and flexing of the belt extrudes cake from the weave. After cake discharge, the belt passes round a wash roller and is cleaned on both sides by high-pressure jets, which can be operated either continuously or intermittently, and the amount and force of the spray adjusted to meet operating conditions.



Chemical washes can be introduced through the spray pipes to ensure complete cleaning. Belt alignment is maintained automatically by movement of a special roller. Sensing micro-switches detect belt movement, and an electro-pneumatic mechanism capable of moving one-half of this roller in either direction along its axis corrects the position of the belt. A range of filter media is available to meet the requirement of any task. A special corrosion-resistant woven metal belt with an exceptionally long service life can be used with coarse or fibrous solids. Belts resistant to almost any form of chemical attack can be chosen from a range of modern synthetic fabrics. The filter will operate continuously at 80 to 90% peak capacity, performing as efficiently at the end of a run as at the beginning.

WALKER, CROSWELLER & COMPANY LIMITED, CHELTENHAM, GLOUCESTERSHIRE



how does the effluent flow ?

No magic wand can disperse the effluent of a factory or works; yet the necessity for control, if our rivers and lakes are to be kept clean, is obvious.

The first essential is measurement and an accurate record. The Arkon liquid flow recorder measures, and records the flow, of any effluent from the corrosive to the merely noxious. The recorder is simple, accurate, easy to maintain and is very low priced.

MORE ABOUT ARKON RECORDERS IN OUR ILLUSTRATED LEAFLET

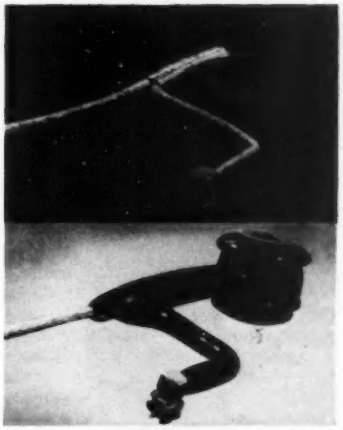
Simple Tool for Removing Corroded Nuts

Based on the original American design but stated to incorporate a number of improved features, the new Barrus nut-splitter produced by E. P. Barrus (Concessionaires) Ltd., of London, W.3, is a simple tool designed to overcome easily and rapidly the problem of removal of corroded nuts, whether permanently rusted or "frozen" to bolts. The tool comprises a chrome-molybdenum steel cutting blade which fits into either of two cast-steel bodies. Each body has a hollow tapped shaft, down which the cutter moves, and an opening ($\frac{3}{4}$ or $1\frac{3}{16}$ in.) to receive the nut to be split. Of robust construction, the nut-splitter is designed to give years of hard service and can cut up to 100 nuts before re-grinding of the blade becomes necessary.

Operation is extremely easy, merely involving selection of the body with the most convenient hole size, insertion of the cutter, and slipping the unit over the nut. The hexagonal rear end of the cutter is then turned with a spanner, each turn causing the cutter head to penetrate further into the body opening and finally splitting the nut cleanly away from the bolt. The whole operation takes less than 2 min, and there is no damage to the thread.

Hard-Setting Universal Plastic Putty

A new universal plastic putty, designated "Talurit", produced by Cable Covers Ltd., of London, S.W.1, is extremely malleable in the as-supplied condition, so that it can easily be worked and shaped, but sets extremely hard after curing, its ultimate compressive strength being about 11,200 psi and its ultimate tensile strength about 700 psi. The putty consists of two separate components, i.e., a resin and a hardener. When these components are completely integrated—a simple operation which can easily be effected by kneading them between the fingers or hands—a readily workable compound results, which will adhere to all materials and which will cure itself naturally in from $1\frac{1}{2}$ to 18 hr, depending on temperature conditions. The cured material remains dimensionally stable and combines considerable hardness and strength with good electrical insulation properties and exceptional resistance to oil, water, and other compounds.



The cured putty, which can be machined, drilled, tapped, or threaded, can be used in a wide range of applications, including repair work, such as leaks and weaknesses in vessels, and for sealing cracks and holes in pipes, etc., as well as for the structural joining of materials and components. Some of its electrical applications include its use for repairing or even replacing porcelain and plastic insulators, bushes, terminal blocks, and similar items, for providing metal tools with an insulating cover, and for insulating or waterproofing terminals, conductors, cable ends, and cable joints. A typical application is given in the illustration, which shows a house-service electric cable joint before and after insulation and protection.

Methods of Generating and Heating Plasma

(*Concluded from page 112*)

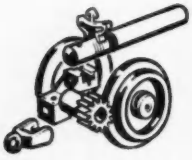
electron beam with a gas. At the Sperry Gyroscope Co., an electron beam fired by a gun into a drift tube containing hydrogen has yielded plasma of 10^{11} particles/cm^3 density at pressures around 1 micron Hg. The 600-V electron beam is focused by a longitudinal magnetic field, while a slight positive potential at the ends of the tube maintains the plasma in a uniform condition. In this case, the ionization mechanism is the kinetic energy of the beam; this differs from an electrical discharge in that no field gradient is maintained. Thus, the technique allows the production of uniform rates of ionization per unit length.

A method of generating highly ionized, steady-state plasmas, as used in several laboratories, combines thermionic electron emission with contact ionization of caesium vapour. At the Hughes Research Laboratories, densities above 10^{12} ions/cm^3 at 90% ionization have been measured in a quiescent plasma column generated by equipment in which ions are emitted by the contact ionization of caesium on two hot tungsten plates, and electrons are emitted thermionically at the centre of the plates. Plasma is thus continuously generated at both ends of the 10-cm column, which is 1 cm in diameter. A direct-current magnetic field of the order of a few hundred oersteds minimizes radial plasma diffusion providing a well-defined quiescent column. Densities, above 10^{14} electrons and ions per cm^3 are considered possible over smaller volumes with this technique.

. . . ring who?

Ring Wragby—yes that's right, Wragby the people for plastics! No bother, just pick up that telephone and listen to the answer to your plastic problem. It's really quite astonishing what they produce these days—gears, pulleys, bushes, bearings, brackets, gliders, washers and clips all produced in nylon. And of course nylon is THE moulding medium for precision, wear, smooth and silent running. Marvellous!

Apart from nylon these Wragby people cover the whole field of thermo-plastics and it costs nothing to talk. They even offer the full facilities of their design and development staff.



This 'cannon' is made up from nylon mouldings produced by us for various applications: breakdown available on request.

WT/B1389

So ring Wragby, and ring 'em NOW!
Nylon for Engineers
—WRAGBY 383/4/5.

WRAGBY PLASTICS

THE PEOPLE FOR PLASTICS

Wragby Plastics Ltd · Wragby · Lincoln
TELEPHONE: WRAGBY 383/4/5

ADDITIONAL ABSTRACTS

Applications of Predictive-Control Systems

By H. CHESTNUT, W. E. SOLLECITO, and P. H. TROUTMAN

From *Applications and Industry* (*A.I.E.E.*), U.S.A., No. 55, July 1961, pp. 128-134, 13 illustrations.

PREDICTIVE control is a form of automatic control in which the manipulated variable operating the controlled system is actuated by an estimate of the error which will exist at some future time. Repeated estimations of this error are obtained by predicting ahead, on a fast-time base, both the reference and the controlled variable, as well as some of their lower-order derivatives. Data-smoothing and prediction of the reference may be required, and the use of a model of the controlled system is needed.

Predictive control appears highly attractive with the availability of small, high-speed logic devices and power-actuating means. With predictive control, any disturbances or reference input value, whether large or small, can bring to bear the full power capability of the power element. As such, with deterministic inputs, faster speeds of response for a given input and power source can be obtained than for a linear system. By virtue of the repetitive prediction calculations, including in the model the major non-linearities or time variations of the process, if necessary, higher gain with adequate stability can be obtained than would be possible with linear means. The equivalent speed of response of the system is markedly dependent on the speed of the repetitive predictions, as well as on the ability of the system to sense its own performance, including its derivatives.

The characteristics of predictive control make it highly attractive in a large number of computer-control applications. Although eminently suited for on-line digital computers, the method can also be used with analogue computing means. Typical fields of application where predictive control appears to be well suited are discussed in this paper, including its use in dynamic chemical-control processes, and in space navigation and rendezvous missions, with the ability to land vehicles to prescribed flight paths.

The experience gained over the last two years in applying predictive control to various control applications indicates that this form of control has definitely desirable characteristics for many high-performance control systems. Because a maximum actuation signal is used, he maximum force capabilities of the controlled system are used to remove initial condition errors and disturbance effects. This allows rapid synchronization with and close correspondence to a wide range of command signals.

A major disadvantage of this form of control lies in the need for a fast-time simulator and a fairly elaborate control logic. The logic described in this paper represents an improvement over past techniques in that it is somewhat simpler and uses a variable-frequency repetition rate for prediction which is highest when the controlled variable is close to the command signal. This effect improves the speed of response and accuracy of the system and reduces the magnitude of any limit cycle that may exist.

Testing Tubing by means of a Pressure-Differential Method

By G. H. SYMONS

From *Materials Research and Standards* (*ASTM*), U.S.A., Vol. 1, No. 7, July 1961, pp. 539-541, 4 illustrations.

IN recent years, the trend in tubing has been to lighter walls, both in seamless plain-surface and finned tubing. Small metallurgical or mechanical imperfections in such tubing increase the likelihood of small leaks, and tests must often be made for pressure tightness. The use of eddy-current methods of non-destructive testing has virtually eliminated quality problems in seamless plain-walled tubing, but is generally unsuitable for application to irregular surfaces on extended finned tubing and to many odd-shaped fabricated tubular parts. For such parts, the most common method of testing involves immersion in a liquid such as water. In certain applications, however, the presence of water is undesirable, and for this reason the test method described in this paper is directed towards determining the soundness of the tubing by its ability to maintain a given air pressure.

In this pressure-differential test, air under pressure is simultaneously applied to two units under test. The pressurized units are then isolated from the pressure supply and, after a time, the pressure in one unit is compared with that in the other unit by means of a U-tube manometer connected between the two units. Any difference in pressure, as a result of a leak in either unit, is readily detected by the relative positions of the manometer columns. The test units can comprise individual tubes or sets of tubes, as required. It is stressed that, for this test method to be successful, it is essential that the equipment be absolutely airtight; otherwise, the result could well be the rejection of sound tubes. The tubes to be tested are inserted into a fixture which has heads to clamp and seal both ends, one head serving to "dead-end" the tube, while the other incorporates the inlet, exhaust, and manometer connections. The U-tube manometer is a 50-in. type equipped with vent checks to prevent sudden surges in pressure from blowing out the indicating fluid.

The advantages of this simple test method are that it has greater accuracy than conventional methods and that it eliminates the need for immersion in a liquid, thus permitting the tube or parts to remain clean and dry. Furthermore, it is adaptable to automation by means of suitable automatic loading and unloading equipment and sensing devices. It should also be noted that it has an

"any other form of water heater would have been extortionate"

and not so convenient, immediate, or economical.

The Works Director was talking about Leonard steam water heaters which, from available steam and cold water lines, provide abundant thermostatically-controlled water at low cost.

It all began with a note to

WALKER CROSWELLER AND COMPANY LTD., CHELTENHAM, GLOUCESTERSHIRE.

inherent "fail-safe" feature, in that malfunction of the equipment will not pass defective tubes, though it might, as already mentioned, reject sound tubes. Still another advantage is that it reduces operator fatigue. Thus, there is no need to observe the entire part under test, but only the manometer. Also, operators are not faced with the difficulty of deciding whether a bubble adhering to a tube surface is the result of a minute leak or merely the result of entrapped air, and, in the case of long lengths of tubing or intricate shapes, less manpower is required.

Lubricants for Nuclear Reactors

By P. E. B. Vaile

From a paper presented at a meeting of *The Institution of Mechanical Engineers*, London, September 14, 1961, 24 pages, 19 illustrations.

The advent of nuclear power has brought new problems in lubrication. Thus, nuclear lubricants, in addition to the normal functional requirement, must withstand radiation and high temperatures, must be able to operate in atmospheres of carbon dioxide and possibly helium over a wide range of pressures, as well as in air, and must be non-reactive towards reactor materials, particularly fuel-can metals. In fact, the earlier British carbon-dioxide-cooled, graphite-moderated power reactors were designed to operate without lubrication. This was necessitated by lack of knowledge of the effects of radiation and other reactor operating conditions on lubricants, and of the degree of compatibility of lubricants with reactor materials. Investigations carried out over the past few years into the effects of nuclear radiation on many types of lubricant have shown that it is possible to produce materials capable of lubricating some reactor components. In order to further the development of such lubricants, the U.K. Atomic Energy Authority and the nuclear manufacturing groups have co-operated in providing lubricant manufacturers with details of design and operating conditions of the reactor components which it is desirable to lubricate.

This paper describes the range of operating conditions which lubricants are expected to encounter in different reactors, with particular emphasis on the CO_2-cooled, graphite-moderated reactor. Nuclear lubricant requirements proposed by the U.K.A.E.A. to cater for many applications are also discussed. With this information, it is now possible to assess realistically the types of test facility necessary for the evaluation of nuclear lubricants. Such test facilities are described and include irradiation sources, a test rig for running under irradiation conditions, various test rigs to simulate reactor operating conditions for testing products both before and after static irradiation, and other specialized equipment. The effect of radiation on both conventional and nuclear lubricants is described and the use of "anti-rads" illustrated. Attention is drawn to other desirable properties of nuclear lubricants, such as temperature stability, low volatility, and compatibility with reactor and fuel-can materials.

Designers of reactor machinery have taken, and will increasingly continue to take, advantage of the developments in lubricants, and further advances in lubricant quality will undoubtedly be made. It must, however, be appreciated that, although there is still scope for producing speciality nuclear lubricants which will withstand higher temperature and radiation levels than current products, design trends indicate more severe operating conditions in the future. Thus, there will still be conditions which necessitate the dry running of moving parts in some reactors, although this will be minimized.

Welding an Ultra-High-Strength Steel for Solid-Propellant Rocket-Motor Cases

By J. F. Rudy, J. I. Fisher, J. P. Sheehan, F. Suyama, and H. Schwartzbart

From *Welding Journal*, U.S.A., Vol. 40, No. 6, June 1961, pp. 241s–252s, 13 illustrations.

Solid-propellant missiles have created an immediate demand for ultra-high-strength, low-weight pressure vessel materials. Several alloy types have been given consideration as possibilities for filling this demand, but the alloy involved in the investigation described in this paper is representative of low-alloy high-strength steels, developing its strength by a quench-and-temper heat-treatment cycle. The particular alloy concerned has a high silicon content, which serves to increase the optimum tempering temperature for high strengths to 600°F, and is designed for an ultimate strength level of 280,000 to 300,000 psi, with a yield strength (0·2% offset) of about 230,000 psi.

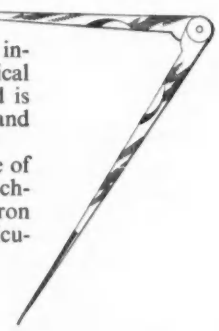
As described in this paper, studies have been made in connection with the problems associated with the fabrication of this steel for solid-propellant rocket-motor cases. Specimens of various geometrics were joined by arc-welding, the tungsten electrodes used being of a standard 1% thoriated type. The shielding gas on the torch side of the weld was argon, and helium on the underside of the weld.

The behaviour of the weld joints was evaluated after heat treatment in various ways under uniaxial loading, both transverse and parallel to the direction of welding, and under biaxial loading. The three loading systems provided an evaluation of the mechanical behaviour of the weldment specimens after standard heat treatments and after various special treatments, including minor heat-treatment variations, surface decarburization, and cold-rolling. It was possible to find treatments which appreciably enhanced the ability of the specimens to strain prior to fracture—particularly those specimens containing flaws—while maintaining satisfactory engineering strengths.

Following full heat treatment, satisfactory welds were obtained in this material in 0·08-in. sheet sizes as large as 12 × 12 in., and in small pressure-vessel girth welds, with no observed cracking difficulties and with no preheat requirements indicated. The ultimate strengths of properly heat-treated welded specimens, loaded uniaxially (both longitudinal and transverse to the welding direction) and biaxially, ranged from about 240,000 to 280,000 psi, with yield strengths between 205,000 and 250,000 psi.

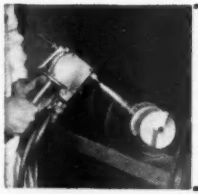
material answer

Sintox—the alumina ceramic of exceptional insulation characteristics, has great mechanical strength, excellent thermal conductivity, and is resistant to corrosive atmospheres, solutions and conditions.
Its characteristics are such that Sintox can be of service in the Electrical, Electronics and Mechanical Engineering Industries and its low neutron capture cross-section makes the material particularly valuable in nuclear applications.



to design problems . . .

Sintox Ceramic Nozzles are employed in the British Oxygen Argon—Arc Welding Process.



Lodge have developed an alumina spraying process giving thermal and erosion protection. Special leaflet on request.

SINTOX A PRODUCT OF LODGE

Sintox Technical Advisory Service freely available without obligation. Please write for booklet

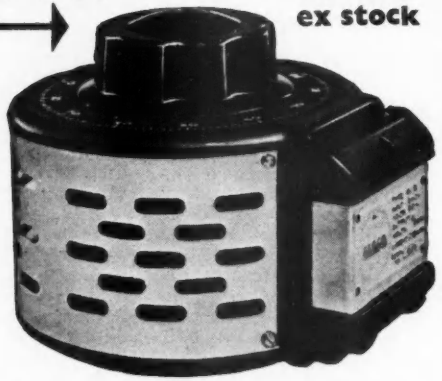
precision engineering ceramics

LODGE PLUGS LTD., RUGBY, ENGLAND. Telephone: Rugby 2166

A UNIVERSAL A.C. VOLTAGE & CURRENT CONTROL

. . . with universal fixing centres

Delivery ex stock



For the most up-to-date variable transformers . . . for early delivery, too, the obvious choice is the Berco Rotary Regavolt, model 42A, rated at 580 V.A. With a maximum input voltage of 250 V. it will supply a variable output from 0-270 V. Moderately priced at £7.0.9*d.* (skeleton type) and £8.5.11*d.* (protected type as illustrated) the Berco Rotary Regavolt represents the finest value today at the lowest cost.

- **CONSTRUCTION:** Toroidally wound auto-transformers, with tracks formed on one face of the windings.
- **CORE:** Wound from a continuous strip of low loss electrical steel in a similar manner to the well-known C core construction.
- **INSULATION:** Specially processed plastic mouldings ensure minimum shrinkage due to heat and continuous use, and prevent any possibility of the turns slackening.
- **WINDING:** Of high conductivity copper, insulated with a synthetic enamel of the polyvinal acetal-phenal formaldehyde resin type, giving good space factor, exceptionally high abrasion resistance and prolonged heating resistance.
- **FRAME:** Of die cast aluminium, incorporating long spindle bearings and mounting feet to ensure accuracy and rigidity of the mechanism in relation to the fixing holes.
- **BRUSHES:** The brushes are of a special carbon for its contact resistance characteristics, shaped to give minimum loss, maximum strength and longest life.

BERCO

** Write for list 615A giving full technical details of this and other models in the Rotary Regavolt range.*

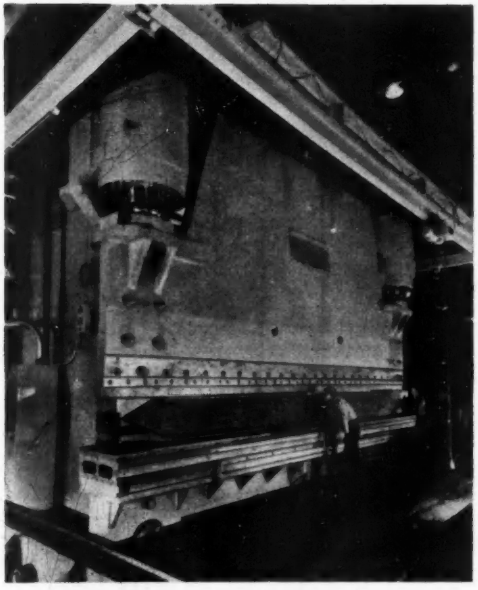
THE BRITISH ELECTRIC RESISTANCE CO. LTD.,
QUEENSWAY, MIDDLESEX
Telephone: HOWard 2411 Telegrams: Vitrohm, Enfield
Specialists in the control of current and voltage for more than 25 years

BRI341-BXH

New Materials, Processes, and Equipment

Large Hydraulic Metal-Bending Press

A new hydraulic metal-bending press, constructed by the Allsteel Press Company, of Chicago, Ill., has recently been installed in the factory of the largest American firm of builders of electric mining shovels and overhead travelling cranes, where it is used for shaping such components as trolley sections for cranes, excavator dipper sticks, bucket shells, cable drums, and cab base frames. Capable of delivering a pressure of 2000 tons—sufficient to shape large sections of high-strength alloy steel of 26 ft width and 1¼ in. thickness—this machine is believed to be the largest and most powerful metal-bending press in the world. The press, which weighs 250 tons, covers more than 350 sq ft of floor space and rests in a pit 11 ft below floor level, its height above the floor being over 21 ft. The bed is 26 ft in length by 2½ ft in width, and the press has a stroke of 24 in. Pressures up to 3000 psi are used, the hydraulic pumps being driven by a 200-hp motor.



The machine can perform in one bending operation many of the same jobs previously requiring as many as five strokes with conventional machines. At the same time, it permits the use of higher-strength alloy steels than would normally be practicable from the point of view of production. Nevertheless, despite its size and power, it requires only one operator and assistant to handle even the heaviest of jobs. A complex control system permits selection of four different pressing speeds in increments of from 5 to 24 ipm, depending on whether the press is being used for punching, medium forging, or heavy forging. A rapid-advance speed of 180 ipm and a rapid-return speed of 135 ipm are incorporated. A special automatic governing control in the hydraulic system constantly maintains the ram in a level position. Thus, if one cylinder lags, the system automatically bleeds oil from the leading cylinder and feeds the lagging cylinder. A method of tilting the ram for use in forming conical shapes has also been provided, a simple hand-wheel adjustment setting the required angle of tilt.

Stainless-Steel Liquid-Level Alarm Switch

The latest addition to the range of packless flexible-shaft level controllers manufactured by the Instrumentation Division of Associated Electrical Industries Ltd. at Harlow, Essex, is their Model 26S liquid-level switch, which is of particular interest to the food-processing industry inasmuch as its carbon-steel flange is clad with a stainless-steel plate, presenting to the process an unbroken surface. The switch and terminal housing is insulated from the flange by an asbestos gasket, permitting it to be operated at process temperatures up to 350° F with adequate ventilation. The switch is easy to install, has no rubbing parts, and is capable of direct or reverse action.

The switch is operated by a change in the buoyancy of a stainless-steel displacer unit, and not by the movement of a float riding on a changing liquid level. Any displacer motion is transmitted to a micro-switch by a stiff tongue in a stainless-steel flexible shaft, stop arms (also of stainless steel) being provided to ensure that the stress in the flexible shaft is kept within the elastic limit.

Miniature Transistorized Sound-Level Indicator

Designed to cater for the need for a simple instrument of lower cost than conventional sound-level meters in many of the less exacting applications in connection with simple measurement and reproducible comparisons of sound levels, the new Type 1408D sound-level indicator announced by Dawe Instruments Ltd., of Brentford, Middlesex, is an extremely compact transistorized instrument which is easy to read and simple to operate. Measuring only 6 × 3 × 2¼ in. and weighing 14 oz, complete with battery, it is believed to be the first truly pocket-size sound-level indicator, but nevertheless incorporates an amplifier of outstanding stability, performance being virtually unaffected by a 30% reduction in battery voltage and by normal variations in ambient temperature.

The instrument uses a high-sensitivity Rochelle-salt crystal microphone which feeds into a special high-input impedance circuit. This circuit is followed by a four-position attenuator and buffer stage, the output from this section being applied to a two-stage amplifier with three associated resistance-capacitance weighting networks (standard weighting curves *A*, *B*, and *C*, the *C*-network being essentially flat from 32 to 8000 cps

DRIVE FOR SMOOTH PRECISION WITH INDUSTRIAL DIAMONDS

The finest pistons are turned with diamond tools and, for matching precision, their con-rods are honed with diamonds.
Industrial diamond tools cut, grind, and polish with unsurpassed speed and accuracy and so make a vital contribution to increased efficiency and production in thousands of engineering processes.

To find out if diamond abrasives, diamond tools or diamond impregnated wheels can help you in *your* problem, please get in touch with the Industrial Diamond Information Bureau. This Bureau is backed by the world's largest laboratory devoted to diamond technology – The Diamond Research Laboratory in Johannesburg. For information and advice, without obligation, please write to the address below.

I D
I B

The Industrial Diamond Information Bureau

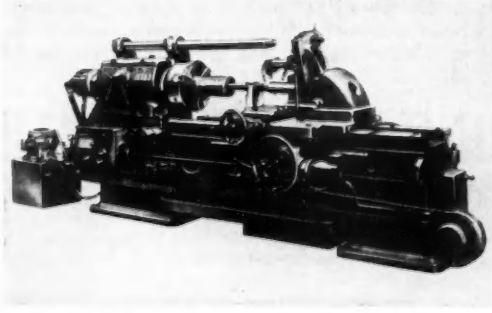
2 CHARTERHOUSE STREET (DEPT. 3), LONDON, E.C.1
Telephone: Fleet Street 7157

approximately) designed to conform with the proposed I.E.C. specification for sound-level meters. The output of these networks feeds into the meter-amplifier circuit. This two-stage system has the meter and rectifiers in a negative-feedback line to provide good scale linearity. Both amplifier sections have been designed to have very stable gains which are virtually unaffected by transistor-parameter variations or supply voltage, the mode of construction employing a printed circuit with "end-mounted" components, resulting in a high component density and a considerable saving in space. The attenuator covers the range between 70 and 100 dB in steps of 10 dB. As the meter, which is of the moving-coil type with special ballistic properties, is calibrated from −6 dB to +10 dB, the instrument can be used to cover the sound-level range from 64 to 110 dB. Power is derived from a 9-V dry battery with a life of about 80 hr. A battery-voltage check is incorporated.

Heavy-Duty Turning, Boring, and Parting-off Lathe

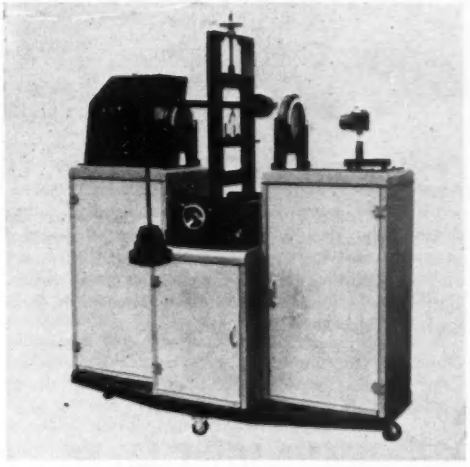
Designed for turning, boring, and parting-off ferrous and non-ferrous bar and tube, and also for the repetition machining of items such as cylinder liners, the new 10½-in. heavy-duty centre lathe announced by The Crowthorn Engineering Co. Ltd., of Reddish, near Stockport, has a swing over the slideways of 21 in. and a swing over the saddle of 13 in. The standard model has a straight bed, 10 ft 3 in. in length, but, if required, the machine can have a gap to swing up to 36 in. diameter by 15½ in. width. The standard headstock is of up-to-date design and provides a range of twelve speeds, from 16 to 453 rpm, with a centralized gear-change control. If desired, a high-speed headstock can be fitted in place of the standard headstock, providing spindle speeds up to about 1000 rpm. Other features include a rapid power traverse mechanism for the carriage, an automatic feed trip to sliding motion with an adjustable stop, a mechanism for setting the rapid power traverse in operation after the feed trip has cut out and also to cut out the rapid power traverse at a predetermined point along the bed, an overhead support bar, a knee-type turning tool with an adjustable holder mounted on the boring-bar bracket, a boring bar with toolhead, and two motorized suds pumps, of 8 and 25 gpm capacity respectively.

The model illustrated has front and rear single toolholders mounted on separate tee-slotted cross-slides, each on a separate cross traverse screw, but the mechanism provides various alternatives, enabling the two toolholders to move simultaneously either inwards or outwards, or to move at a fixed distance apart, as though mounted on a single cross traverse screw. In addition, there is a neutral position, so that only one toolholder is in operation. If required, a four-way turret toolpost can be fitted at the front, in lieu of the single toolpost. The lathe shown in the illustration is fitted with a 16-in. Pratt hydraulic three-jaw self-centring chuck with a pump unit and two control valves, one for operating the chuck, and the other for operating the main driving clutch. As alternatives, it is possible to fit four-jaw independent or three-jaw self-centring hand-operated chucks, or a three-jaw self-centring toggle-lever type of Pratt pneumatic chuck, complete with draw-bar, cylinder control, stop-valves, and pressure gauge.



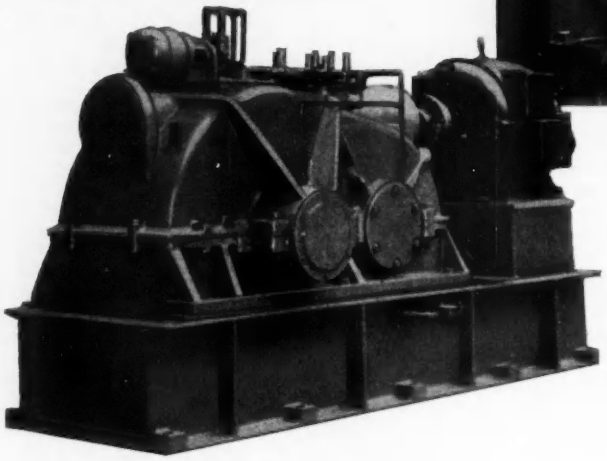
Polariscope for Photo-Elastic Stress Analysis

Polariscopes of the diffused-light type or of the transmission type each have distinct advantages. Thus, the diffused-light polariscope is more adaptable for rapid measurements of results, is more suitable for visual examination, as glare effects from lenses are not present, and enables excellent definition of fringe photographs to be obtained. On the other hand, the transmission type is convenient for group demonstrations, as the images of stress patterns can be projected onto a screen, and the projection system facilitates the drawing of isoclinic lines, which can be traced directly on the screen for various degrees of angular rotation of the polarizer and analyser. Also, the alignments of model boundaries in the image are better with the transmission type of polariscope than with the diffused-light type.



The new Sharples polariscope, announced by the Sharples Engineering Co. (Bamber Bridge) Ltd., of Walton-le-Dale, Preston, Lancs., is unique in that provision has been made for using it either as a diffused-light or as a transmission instrument. As such, it is not only suitable for serious research work and as a practical engineer's tool for the assessment of designs, but is also eminently practical for university and technical college lecture purposes. The instrument is of very compact design and is mounted on its own cabinet, which contains ample storage space for models and for special loading equipment, etc. The Polaroid discs, 5½ in. in diameter, and the quarter-wave plates, all mounted between glass, are carried in cast-aluminium

GEARS ..FOR ALL PURPOSES



UNDER CONSTRUCTION

The 42″ × 108″ Blooming and Intermediate Mill, shown under construction in the Bridgeton Works, Glasgow, of Davy and United Engineering Company Limited (a member of the Davy-Ashmore Group) has now been installed at the Stockbridge Works of Samuel Fox & Company Limited, Branch of the United Steel Companies Limited, as part of a large-scale extension scheme. It will deal primarily with quality steels, producing a wide range of blooms and billets, and will be capable of rolling to a very flexible programme.

The gearing, supplied by STONE-WALLWORK, is totally enclosed running in oil, and comprises a high-efficiency worm gear, combined in one casing with machine-cut spur or helical gears. The latter is divided into two distinctive gears, one on each side of the worm wheel. The whole representing a compact and symmetrical arrangement which ensures an even distribution of the loads between the bearings and gears.

GEARS ..FOR ALL INDUSTRIES

Within the extensive range of Stone-Wallwork Standard Gears, there is a unit of suitable type, possessing the needed capacity and ratio to meet almost every transmission requirement. Where applications cannot be met from the standard range of gears, suitable transmission units can be specially prepared.

Also manufacturers of the

PIV

POSITIVE INFINITELY VARIABLE
GEAR BOX

STONE-WALLWORK LTD

32 VICTORIA STREET, LONDON, S.W.1

Telephone: ABBey 7681
Telegrams: "Stonewalabb" Sowest, London
Works: Bleasby Street, Oldham, Lancashire

STONE PLATT GROUP

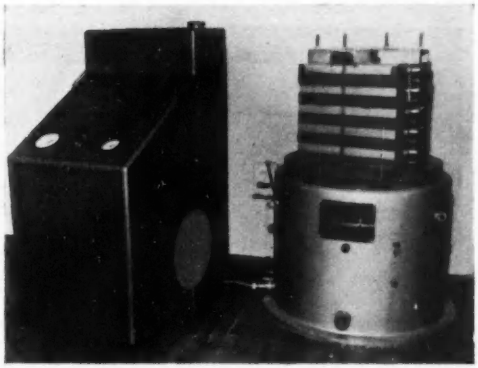
housings and can be rotated separately through 360 deg., as required, the degree of rotation being conveniently read from scales fixed to their housings. All these items can be readily removed, if desired, though it should be pointed out that the optical effect of the quarter-wave plates can be cancelled out by setting each plate to an appropriate position without their actual removal, this being necessary when plane polarization is needed for examination of isoclinics. Resetting of the quarter-wave plates quickly converts the polariscope back into a circularly polarized instrument for examination of the isochromatics. The loading frame is of robust construction and is universal in its application to model loading, which is normally effected through a lever and dead-weight system. Tensile, compressive, flexural, and torsional loads can conveniently be applied. Provision is made for vertical and transverse movements of the loaded models, and a swivel movement is also provided for adjustment of space effects. The camera stand can be adapted to take any 35-mm camera, and other larger cameras can also be used, if desired.

For use as a diffused-light instrument, a 60-W tubular sodium-vapour lamp for producing monochromatic light is employed, together with two 150-W tungsten filament lamps for white-light illumination, all these lamps being contained in a detachable lamphouse with an efficient diffusing screen. As it is not advisable to switch sodium-vapour lamps on and off frequently, a rotatable screen is provided to exclude light from the sodium lamp when the tungsten lamps are in use. To convert the instrument to a transmission type of polariscope, all that is necessary is to replace the lamphouse with a special platform carrying a compact 250-W mercury-varpour lamp, a 150-W tungsten filament lamp, and an optical-quality condenser lens of 6 in. diameter. The tungsten lamps can be brought into use by switching on and swivelling a mirror into position, thus directing the white light through the condenser and, at the same time, screening the light from the mercury-vapour lamp. At the other end of the polariscope, a sliding bellows mounting is provided to carry the camera lens, which then serves as a projection lens. A glass screen to accept tracing paper is fitted for receiving the projected image.

Generator for Low-Frequency Vibrations

In many industries, there is a need for a machine which will vibrate such structures as the wings and tailplanes of aircraft or motor-vehicle suspension systems and chassis, with a view to testing their resonance at very low frequencies and, if necessary, to fatigue them until they break. For this purpose, the requirement is for equipment which will generate a large thrust at frequencies down to zero over a long stroke. The new vibration generator announced by Fairey Air Surveys Ltd., of London, W.1, fulfils this requirement by providing a 2000-lb thrust, with a working range from 0 to 50 cps and a maximum stroke of 4 in. at the lowest frequencies. As such, it can be used in applications which cannot satisfactorily be catered for by the current ranges of mechanical or electromagnetic vibrators.

In this new vibrator, both frequency and amplitude are remotely controlled from a power console (combined control unit and power pack) and can be varied while the equipment is in operation. The vibrator unit utilizes a hydraulic jack actuated by an electrically

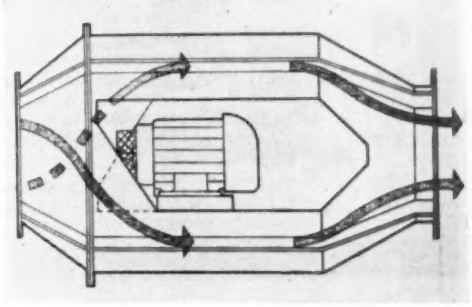


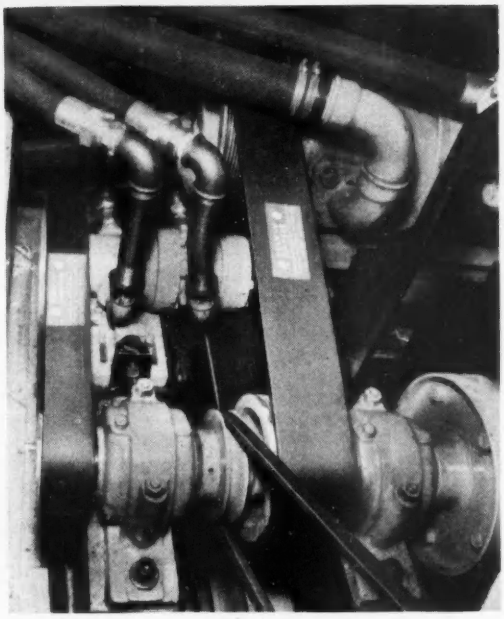
signalled valve and is connected to the power console by two high-pressure hydraulic lines and one electrical control cable. The equipment is supplied complete, no additional amplifiers, oscillators, or output transformers being necessary. The vibrator itself weighs 1100 lb, and the power console 600 lb.

The ability of the equipment to maintain a dynamic thrust of 2000 lb over the full frequency range of 0 to 50 cps means that it is capable of vibrating a component of this weight fixed to the table top and also that it can exert this load on an existing structure, such as a high-set tailplane, through appropriate linkage rods. In addition, in cases where a static load without vibration has to be exerted on a structure, a static thrust of up to 10,000 lb is available with high-precision control. In fatigue testing, this feature can be used to impose a preload on a structure, using the positioning facility of the jack, and vibrations can then be superimposed on this preloading about the deflected position.

Compound-Flow, Bifurcated Fans

The new range of "Ax-Cent" compound-flow, bifurcated fans announced by Keith Blackman Ltd., of London, N.17, differs from conventional axial fans in that a bifurcated duct or casing, as shown in the illustration, provides a built-in motor compartment which protects the motor from the air or gases passing through the duct, while the fan has a Venturi inlet to a shrouded compound-flow impeller. Thus, these fans combine the advantages of both basic axial and centrifugal types. In addition, it is stated that they can develop about twice the pressure of single-stage axial fans running at the same speed, their volumetric and pressure output being more comparable with that of two-stage axial





TURNERS POLY-V (TRADE MARK) **DRIVES**

eliminate the 'V' belt matching problem

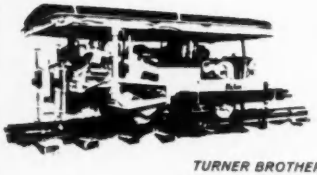
SAVING SPACE, TIME AND MONEY, WHILE TRANSMITTING MORE POWER.

2 "POLY-V" 'L' section Belts have replaced the sets of V-belts in this "JAK-PAK" Ballast Tamper.

With the narrow widths and short centres of the new drives, Matisa have been able to use a much more compact pumping equipment layout, thereby reducing the overall length of the machine.

In all parts of the country, engineers are finding that TURNERS "POLY-V" drive helps them to solve similar problems. It could be the answer also to your power transmission problem. Why not let our engineers work with you and advise on the design of new or existing equipment?

Used for levelling railway lines, the "JAK-PAK" Ballast Tamper is manufactured by Matisa Equipment Co. Ltd., Chertsey.



TURNER BROTHERS ASBESTOS CO. LTD., ROCHDALE, ENGLAND.
A MEMBER OF THE TURNER & NEWALL GROUP.

CW.8218/PV7

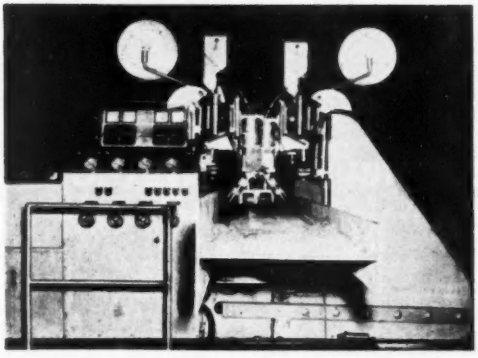
fans. Even so, their low sound level and high mechanical efficiency compare favourably with those of centrifugal fans of equal duty.

These fans are available in sizes of from 9 to 30 in. diameter, with outputs of from 100 to 14,000 cfm. Their pressure range is up to 14 in. w.g. static pressure, and they can be used at temperatures up to 650° F. Owing to their axial-fan configuration, they are easy to install, while their ability to provide comparatively high pressures at an acceptable sound level makes them suitable for numerous applications, particularly in boiler induced-draught work or hot-air recirculation involving temperatures up to 650° F.

Automatic Welders for Producing Profiled Beams

Representing a radical departure from conventional rolling processes, the new automatic profile welder announced by Pullmax AB, of Gothenburg 1, Sweden, is stated to be the first of its kind in the world to produce beams of various profiles by an automatic welding process. In this machine, which is marketed in the U.K. by Pullmax (Great Britain) Ltd., of Blackpool, beams are fabricated from plate which has been precut to the required final thickness and length, and the sections are then automatically welded together to form the desired profile. I-beams, U-beams, and T-profiles, as well as special profiles, can be produced with predetermined web heights and constant flange widths. The machine can also be adapted to weld tubes.

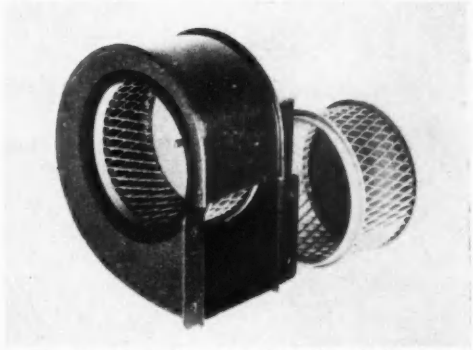
The machine, which has overall dimensions of approximately 15 × 8 × 6 ft high, basically consists of three main units, i.e., an automatic feeding machine, two automatic welding units, and the corresponding welding generators. The feeding machine incorporates an automatically rail-operated table mounted on a heavy frame and powered by electric motors, speed variators, and hydraulic pressure cylinders, the beams being conveyed during welding by hardened, heat-treated feed rollers. One side of the feeder is adjustable to permit welding I-beams with heights between 12 and 60 in. Flat iron for flanges can be used with dimensions between 2 and 20 in. Feeding speed is continuously variable between 0 and 66 ipm.



The two automatic welding units have fully submerged arc-welding heads, each rated at 900 A, and are capable of handling wire sizes up to ¼ in. in diameter. The necessary controls for wire feed are incorporated, using an independent generator for powering the d.c. wire-feed motor. The arc welders are of the constant-voltage d.c. type, and are also rated at 900 A each. The use of d.c. welders of this type is specially suitable for submerged-arc fillet welds, as well as for butt welds. If required, the machine can be equipped with automatic welding heads of other types, to suit individual requirements. All controls for the feeding and welding equipment are conveniently grouped together on one panel for simple push-button operation.

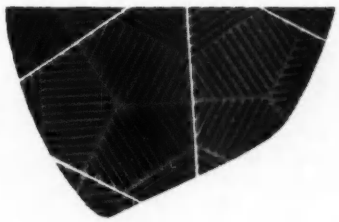
Centrifugal Fans with Mesh-Type Impellers

An entirely new type of fan, developed by Heat Pump & Refrigeration Ltd., of London, S.E.7, is of extremely simple construction, combined with compactness, low price, quiet operation, and high efficiency. Utilizing the centrifugal effect, the new fan, designated the "Mesh Fan", incorporates an impeller formed in mesh such as expanded metal, plastics, or other materials. The mesh has the usual characteristic pattern of diamond-shaped or similar openings, with narrow strands that receive, in the stretching operation during manufacture, small inclinations, forming hundreds of small scooping blades. The mesh, when formed into a cylinder, provides a rigid but very light centrifugal type of impeller. Full production of these fans, with outputs ranging from 25 to 300 cfm, will commence early next year, but a small fan of 4 in. diameter, with an output of 70 cfm, will be on the market shortly.

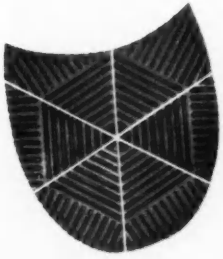


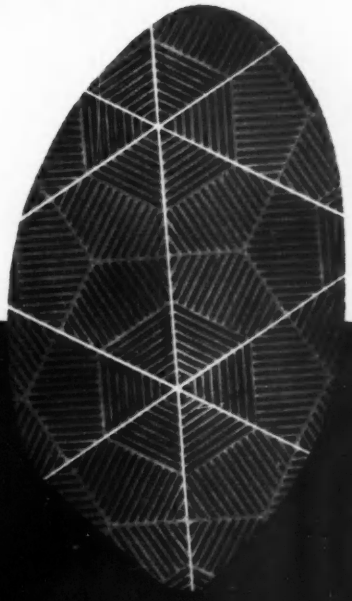
The complete fan comprises the shaft-mounted impeller, with an end-plate or diaphragm, the whole assembly being fitted into a scroll-shaped housing to collect and direct the air, as required. When the impeller rotates, the air thrown off radially by centrifugal force is collected in the scroll and is scooped out by the small blades of the mesh. The scroll converts the high-velocity pressure existing at the blade tips into a static pressure, and for this reason the mesh-type fan is capable of overcoming the resistance of such items as filters, coils, and heater elements. In the case of ventilation, the higher outlet velocity obtained with this type of fan is of importance, as it enables back-draughts caused by adverse winds to be considerably reduced. Also, because the fan has a greater number of small blades and a low inertia, it has the advantage that its speed can be increased without any appreciable increase in noise. For some applications, e.g., in tangential-type fans, semi-scrolls can be used. In addition, the fan can be provided with both forward- and backward-curved types of impeller, to suit any particular requirements.

360° SAFE
with SEEGER CIRCLIPS
Automotive Engineering Limited
The Green, Twickenham, Middlesex
Telephone :- POPesgrove 2206/9
Telegrams :- Motif Twickenham
ONE OF THE SHEEPBRIDGE ENGINEERING GROUP
SEEGER CIRCLIPS ARE ON THE ROLLS-ROYCE APPROVED LIST



Basic steps to INDUSTRIAL SAFETY

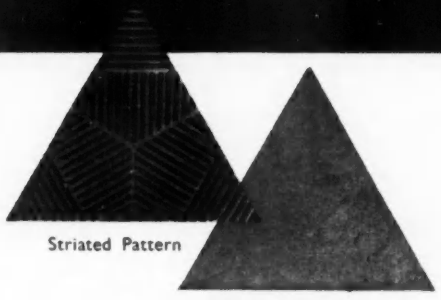




In the shape of an equilateral triangle providing three point foundation which prevents rock and danger from projecting units, Tri-Pedal iron flooring is hygienic, dustless and will stand up to severe traffic conditions.
The flooring is impervious to water, oils, grease and acids generated in manufacturing processes and is unaffected by extremes of temperature.

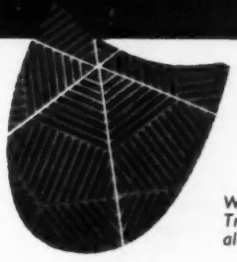
BUTTERLEY

TRI-PEDAL IRON FLOORING



Striated Pattern

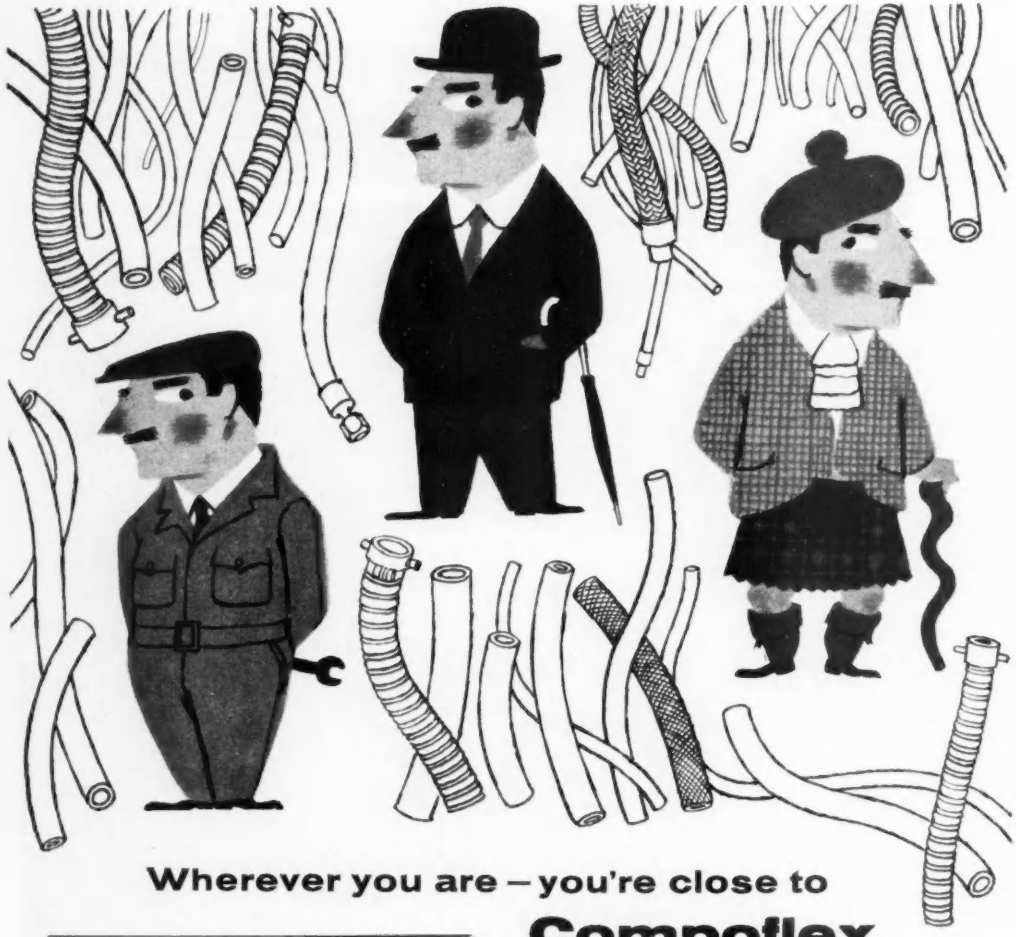
Plain-Surface Pattern



Write for our new leaflet of a Tri-Pedal Iron Flooring which also gives laying instructions.

THE BUTTERLEY COMPANY LIMITED · RIPLEY · DERBY · ENGLAND · Telephone: RIPLEY 411 (9 lines)
London Office: 9 UPPER BELGRAVE STREET · S.W.1. Telephone: SLOANE 8172/3

TP. 22



Wherever you are – you're close to

Compoflex
service

BRITAIN'S LARGEST PIPE/HOSE/TUBE SERVICE

Pipe needs ? Special types—or stock requirements ?
Get them—and get them fast—from COMPOFLEX. Strategically-situated warehouses can meet your requirements quickly—from stock. The unique COMPOFLEX services can develop special types for special jobs. Extensive technical literature is available.
For all these services—get in touch with COMPOFLEX.

THE RANGE OF TYPES: *Air hoses (composite), suction and delivery hoses (composite), rubber hose, seamless metal flexibles (helical and parallel convolutions), interlock metallic flexibles (exhaust and pressure types), plastic tubing (P.V.C. and polythene). These types in hundreds of sizes and gauges provide an almost unlimited range of pipe/hose/tube from stock.*

Use these central warehouses—write, 'phone, call:

LONDON
Angel House, Pentonville Rd., N.1
TER 0533

BIRMINGHAM
9/11 Bordesley Green Rd, Birmingham 9
VICTORIA 0407/8

OLDHAM
Huddersfield Rd., Oldham
MAIN 8114 (5 lines)

EDINBURGH
28 Baltic St., Edinburgh 6 LEITH 36407

GLASGOW
13 Bath St., Glasgow DOUGLAS 3260

Compoflex
CO LTD

HEAD OFFICE: PADDOCKHALL ROAD, HAYWARDS HEATH, SUSSEX
TEL: HAYWARDS HEATH 1831/5

TGA GF 31 C1

Here are the tools for increased production

These specially designed lightweight tools, incorporate the latest refinements. They meet the requirements of the modern workshop and assembly lines for all light duties.

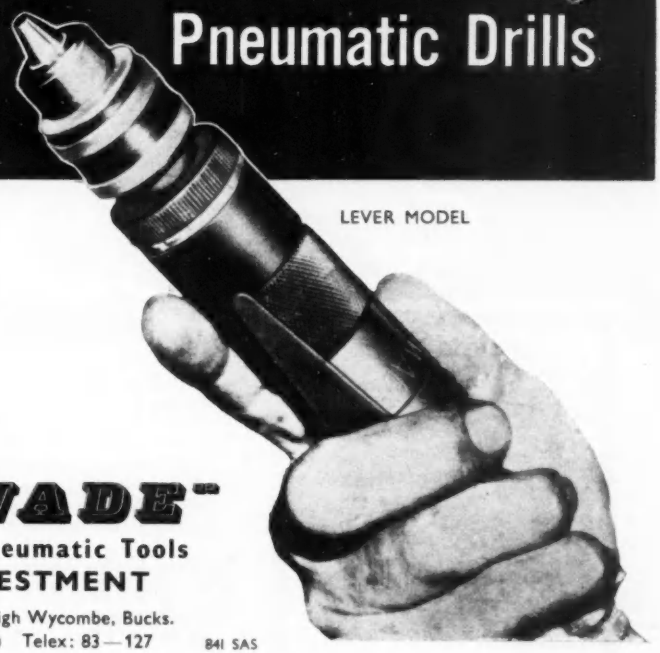
WRITE FOR PUBLICATION NO. 439 T.E.

PISTOL MODEL

ARO-BROOMWADE

Lightweight Pneumatic Drills

LEVER MODEL



★ **Both models weigh less than 1½ lb.**

★ **Best power/weight—power/air ratio.**

★ **Positive speed control. Easy to handle.**

"BROOMWADE"

Air Compressors and Pneumatic Tools

YOUR BEST INVESTMENT

Broom and Wade Ltd., P.O. Box No. 7, High Wycombe, Bucks.
Telephone: High Wycombe 1630 (10 lines) Telex: 83—127

841 SAS

SURFACE GRINDER "ATHENA" - Mod. V 1000

Hydraulic movement

Rapid displacement of the head

TECHNICAL DATA

Principal features of the machine:

Table Stroke	1300 mm
Maximum grinding length	1000 mm
Maximum grinding width	270 mm
Width of clamping table	250 mm
Maximum height of work-piece	370 mm
Rapid replacement of head-remotely controlled	350 mm
Wheel diameter ...	275 mm
Automatic vertical feed	from 0.01 to 0.05 mm

TECHNICAL DATA

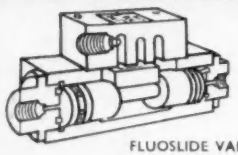
Wheel speed	1400 rpm
Adjustable speed of table	from 1 to 20 strokes per min
Electric Motors (3-phase 50-cps) for:	
Wheel rotation (1400 rpm)	8 kW
Hydraulic unit ...	2.5 kW
Rapid displacement ...	0.3 kW
Cooling unit	0.15 kW
Lubricating pump ...	0.1 kW

OFFICINE MECCANICHE FRATELLI CAMURRI di NEMESIO-ROLO (R.E.)

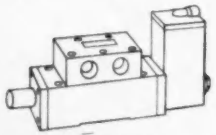
VIA MARCONI, n.7. - Tel. No. 902 ITALY

PNEUMATIC CYLINDERS

FOR EVERY APPLICATION



FLUOSLIDE VALVE.



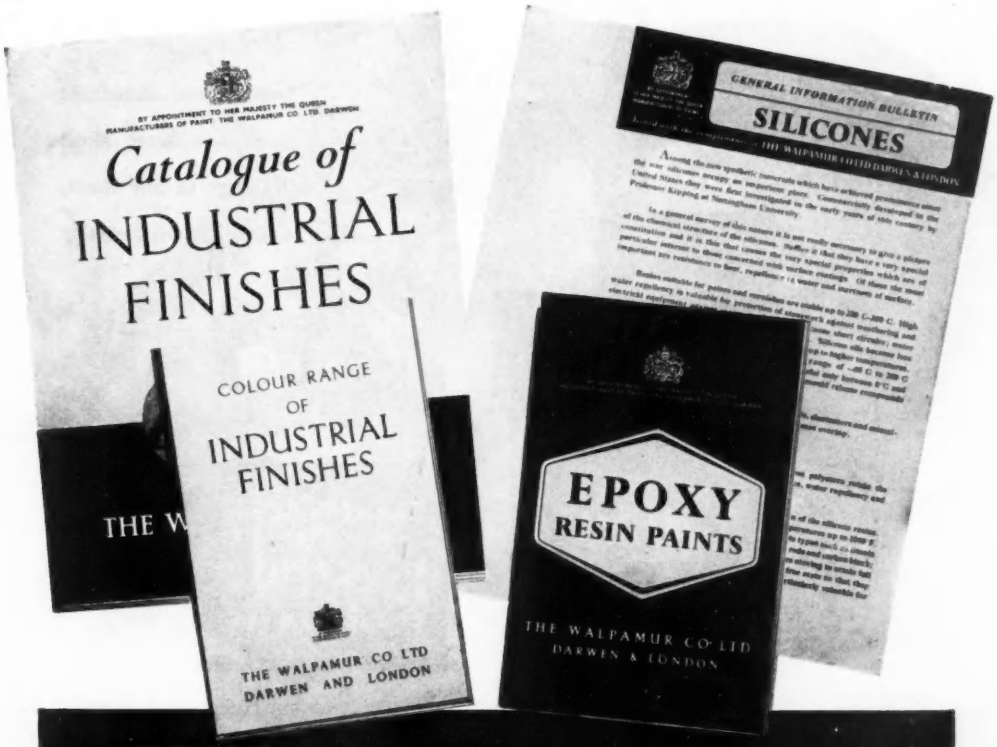
SOLENOID CONTROL VALVE.

With their stainless steel piston rods having replaceable bronze bearings protected by external wiper seals, and also gunmetal end covers and brass or copper barrels, Midland Pneumatic cylinders will give long effective trouble-free service. A choice from nine different mountings. Extra stiff piston rods and cushioned or non-cushioned types, as required, also a complete range of valves and air line fittings. A full technical advisory service is at the disposal of all customers.

MIDLAND PNEUMATIC LTD
NEW CROSS · WOLVERHAMPTON

Ask for latest Catalogue or for a representative to call.

Telephone 32501-2



FOUR helpful publications

Constant research has ensured that Walpamur Industrial Finishes meet every requirement of modern industry, and these four free publications will help you to make the best possible use of this extensive range.

CATALOGUE OF INDUSTRIAL FINISHES describes the pre-treatment of metal surfaces before painting and gives details of primers, fillers and stoppers, stoving finishes,enamels, nitro cellulose finishes etc.

EPOXY RESIN PAINTS booklet details the complete range of FEROX epoxide resin based paints, including stoving, air drying, and cold cure finishes for many industrial requirements.

SILICONE LEAFLET gives information about the use of silicone in heat resisting and water repellent paints, bonding varnishes, etc.

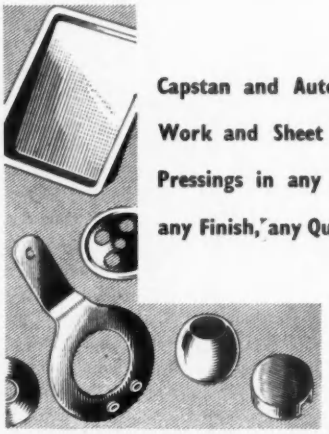
INDUSTRIAL SHADE CARD shows the complete range of colours available for all types of finishes.

All are obtainable free on request to:

THE WALPAMUR COMPANY LIMITED
DARWEN AND LONDON

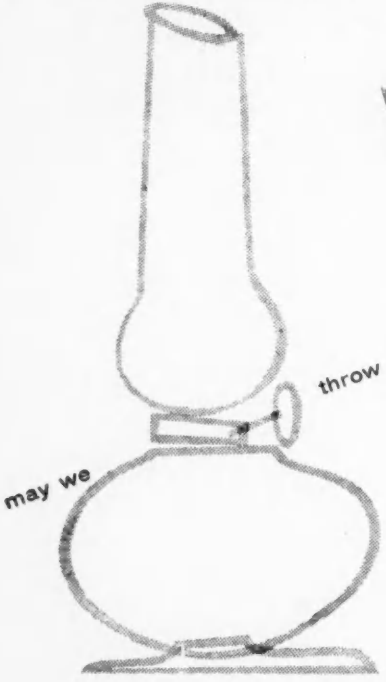
Paints, enamels, varnishes and finishes for every industrial need

BY APPOINTMENT
TO HER MAJESTY THE QUEEN
MANUFACTURERS OF PAINT
THE WALPAMUR CO LTD
DARWEN LANCS



Capstan and Automatic Work and Sheet Metal Pressings in any Metal, any Finish, any Quantity

GRIFFITHS, GILBART, LLOYD,
AND COMPANY LIMITED
EMPIRE WORKS,
PARK ROAD,
BIRMINGHAM, 18
TELEPHONE NORthern 6221



may we

throw some light on the subject of . . . hollow extrusions

. . . a light to guide the designer who seeks more efficient ways of making cylindrical products to close tolerances. In these precision hollow extrusions, the integral ends, with their wide possibilities for internal and external forms, obviate costly machining and assembly.

REYNOLDS

A leaflet No. H.E.15 explaining Reynolds Hollow Extrusions more fully will be sent on request, or our technical staff will be pleased to advise you

REYNOLDS TUBE CO. LTD. · TYSELEY · BIRMINGHAM 11 E9

5000 extrusion dies always on tap for you

Is it extruded sections you need? In copper and copper alloys? ICI Metals Division hold dies for these and 4995 others besides.

For a vast choice of profiles and ready technical expertise, turn to ICI Metals Division.

COPPER & COPPER ALLOY EXTRUSIONS

ICI METALS DIVISION

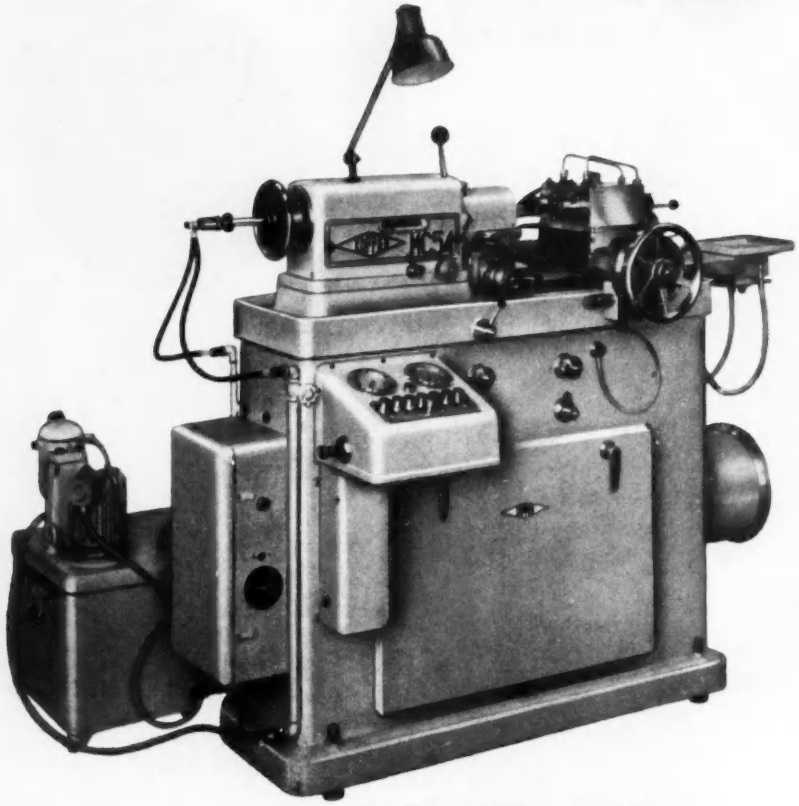
IMPERIAL CHEMICAL INDUSTRIES LTD.
LONDON S.W.1.

C.36a

INTERNAL GRINDER

for production of Injectors
and high-precision components

FRATELLI COPPIER MILANO



TECHNICAL CHARACTERISTICS

Internal grinder for holes of 1 to 20 mm diameter in high-hardness alloys, e.g., gauges, dies, etc. Spindle speeds from 60,000 to 140,000 rpm.— Quick adjustment for control of diameters, with automatic feed of the spindle head: automatic stop — Supply voltage according to requirements. Weight of complete Grinder approx. 750 kg.

CONSTRUCTIONAL FEATURES

Grinder specially designed for the mass production of injectors of any type for the internal grinding of gauges and dies in tungsten, carbide and other alloys, for work requiring a very high degree of precision of the order of 0·0003 mm both in roundness and centricity with surface micro-roughness of 0·00025 mm. Perfectly smooth surfaces are obtained, in view of the complete absence of harmful vibrations The perfect finish of the surfaces, combined with exact geometrical shape, is always assured by the M.C.54 Grinder fitted with patented M.C.52 "Turbo Spindles", with automatic take-up of bearing play, oil-mist lubrication, and other features introduced into its construction. All the adjustments of the individual members of the machine are hydraulically controlled. The machine is fitted with turbine-driven spindles of very high rotational speeds, from a minimum of 60,000 to a maximum of 140,000 rpm; one of these spindles serves to grind cylindrical parts and the other conical parts (e.g. injector and valve seats) according to requirements.

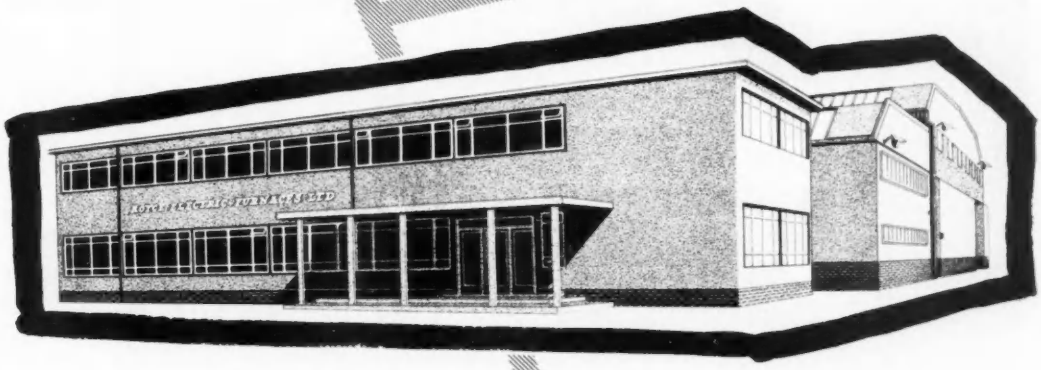
The rotating spindle unit of the M.C.52 "Turbo Spindles" employ a small turbine and the hydraulic system adopted, as compared with electrically-driven spindles, affords numerous advantages, including the following :—

- simplicity of construction.
- variable speed range between the limits required, depending upon the internal dimensions to be ground.
- normal operating speed : 120,000 — 130,000 rpm.
- speed variation between full and no load about 3-4 per cent.
- extremely simple automatic lubrication, without the need for cooling equipment.
- possibility of grinding diameters from 1 to 20 mm.
- automatic take-up of bearing play by means of a patented device which guarantees longer life to the bearings.
- operating life of the spindle at least 800 working hours guaranteed.
- high-precision grinding and finishing of the parts.

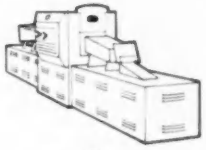
FRATELLI COPPIER-MILANO (ITALY) PIAZZA CARRARA, n.15

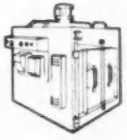
Phone : 84.90.386

a new home for ROYCE 'SPECIALS'



ROYCE furnaces specially designed for your requirements cost no more than standard plant





This new, well equipped factory at Sheerwater, Surrey, is a fitting home for Royce Electric Furnaces—a stable worthy of the thoroughbreds it produces!

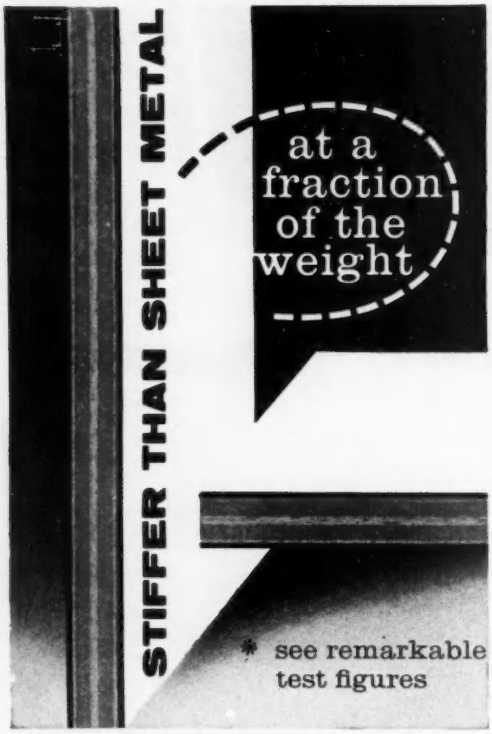
Now more than ever you should specify a Royce furnace. Choose from the comprehensive range of Royce Standards or have a Royce 'Special'—a furnace designed for *you* to meet *your* requirements.

For your new furnace get a quotation from Royce.

ROYCE **ROYCE ELECTRIC FURNACES LIMITED**

ALBERT DRIVE SHEERWATER WOKING SURREY *Telephone: Woking 5401-4*

NRP4097



The new grade of Plymax—STRUCTURAL PLYMAX... two sheets of 26 s.w.g. aluminium or galvanised steel, bonded to a core of exterior plywood... a structural sheet of remarkable stiffness that gives dramatic reductions in weight with all the surface properties of metal.
PLYMAX has been scientifically tested and compared for rigidity, thickness and weight with sheet steel and aluminium; the comparison figures are highly interesting. Analysis results, which completely describe this material structurally, are available in condensed, tabular form for your files. Send for them now.

We are exhibiting at the ENGINEERING MATERIALS & DESIGN EXHIBITION, November 13-18

✻ *Please send me technical data on*

STRUCTURAL

PLYMAX

NAME_____

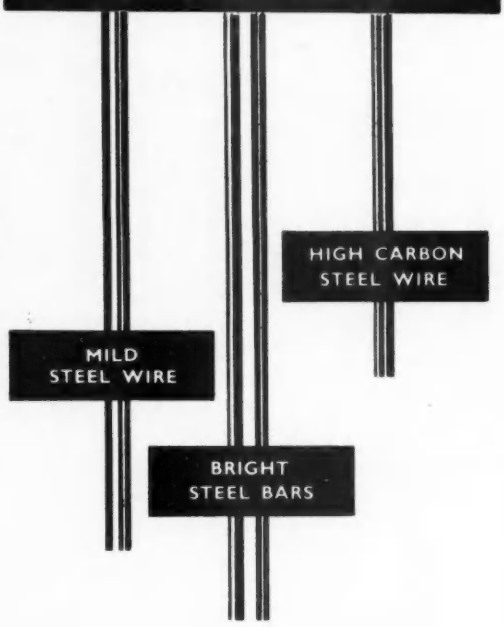
COMPANY_____

ADDRESS_____

VENESTA PLYWOOD LIMITED, Vintry House, Queen Street Place, London, E.C.4. Telephone: CENtral 3040
H21

TA4813

SPENCERS ENGINEERING STEEL



Bright drawn or centreless ground in Mild Steel, Commercial or Free-cutting quality and to a wide range of E.N. and other specifications.

HEXAGONAL **FLAT**

ROUND **SQUARE**

SPENCER WIRE · WAKEFIELD
Telephone WAKEFIELD 6111

DaW 1061 ED

*Super-Vee** combats atmospheric pollution with guaranteed 96% efficiency at minimum cost.

Vokes Super-Vee is an inexpensive, expendable air filter which, because of its unique medium, can offer up to 25% greater capacity compared with similar filters of the same size. This medium, impregnated with a specially developed adhesive, combines high filtration efficiency (guaranteed 96% against Aloxite 50 Test Dust) with long life. Unaffected by moisture, non-cracking, and resistant to fungal growth, it is ideal for the collection of sooty or tarry deposits, *without any danger of fibre migration.*

Vokes Super-Vee, which is fully interchangeable with other filters of its type, is already widely used in applications such as paint finishing plant, chemical laboratories, textile plant, distilleries, nuclear power plant and heating and ventilating installations. Write for details of how it can give *you* high filtration efficiency at lowest possible cost.

FILTER MEDIUM IS FLAME RESISTANT TO BSS 476

VOKES *Registered Trade Name

VOKES LTD · HENLEY PARK · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines).
Telex: 8-535 Vokesacess, Guildford.

Telegrams: Vokesacess, Guildford.
Represented throughout the world.

V562

better fit

FREMO STAINLESS STEEL

Bolts, Nuts,
Set Screws, Studs,
Machine Screws,
Wing Nuts, Dome Nuts,
Flat and Spring Washers

FREDERICK MOUNTFORD (BIRMINGHAM) **LIMITED**
Fremo Works, Moseley Street, Birmingham, 5
Telephone : MIDland 7984 PBX *Telegrams :* Fremo, Birmingham

USE HOLDENS

'POLYPRYME'.
MULTI PURPOSE PRIMER

AIR DRIES IN 10 Mins.

OVERCOAT WITHIN 1 Hr.

with air drying or stoving enamels, hammer or shrivel finishes, low bake epoxy coatings, cellulose lacquers, decorating paints.

BRUSH, SPRAY, DIP

for STEEL · ALUMINIUM BRASS · COPPER

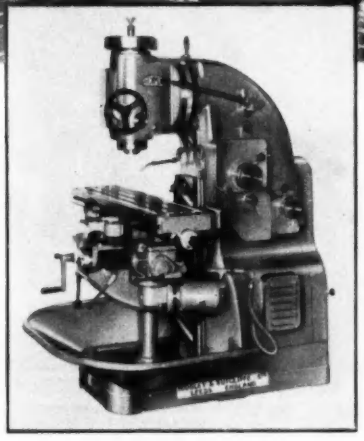
MAZAK · ZINTEC HARDBOARD

AH

ARTHUR HOLDEN & SONS LTD.
Bordesley Green Road · Birmingham 9 Tel. Victoria 2761

ENGLISH STEEL CORPORATION LTD

Choose RICHMOND Machine Tools



Illustrated above is the No. 3 Richmond Vertical Milling machine selected by English Steel Corporation Ltd. from the extensive range of "RICHMOND" Milling machines. Built from the finest materials and incorporating first-class workmanship, all "RICHMOND" radial drills and milling machines are simple to set up, easy to adjust and combine high productivity with exceptional accuracy.

Stocked by leading machine tool merchants throughout the country, "RICHMOND" range the world over!

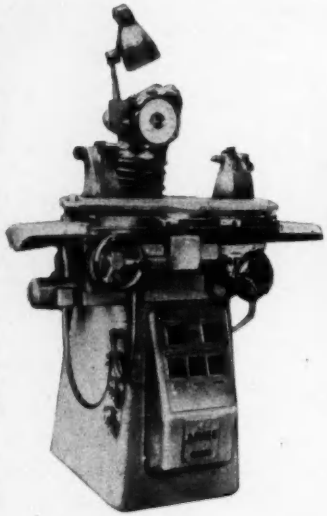
Please send for fully comprehensive Richmond Milling and Drilling machinery literature to:

MIDGLEY & SUTCLIFFE LTD

HILLIDGE WORKS · HUNSLET · LEEDS · 10

Telephone: 76032/3 Telegrams: 'Tools', Leeds, England

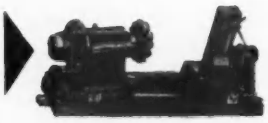
THE 600 GROUP OF COMPANIES



Only

the type 4P
grinding and sharpening
machine
can offer you
such an extensive
range of applications:
all
grinding operations
and the most specialised
sharpening operations.

EXAMPLE:—The sharpening of form-relieved milling cutters
—straight, inclined or staggered teeth
—is easily achievable with our
PROFILE ATTACHMENT
—which, as distinct from other similar equipment, is adaptable to all types of machines.
—Ask for our special leaflet



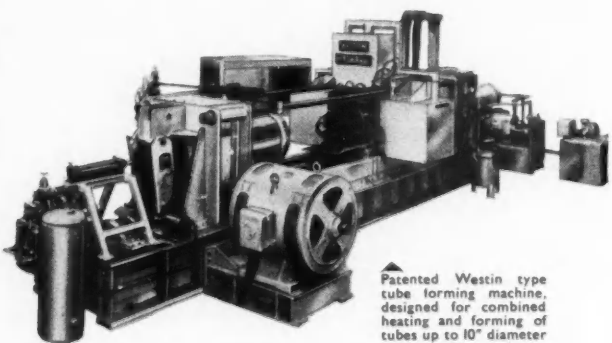
LIVET

Etablissements LIVET et ses fils, 30, rue Ramus, PARIS-20e-PYR. 70-14

Foremost in advanced welding techniques

Specialists in complete design and manufacture of all types of standard and special purpose resistance welding equipment from 1 KVA to 1,500 KVA or greater, and including fully automatic conveyor and hopper fed lines for high speed production requirements in the automobile, aircraft, steel drum and wire industries, and all branches of engineering.

Also designers and manufacturers of:
Special Purpose Jigs and Fixtures
Press Tools and Dies
Electronic Controls
Tube Mills
Cycle Rim Forming and Welding Equipment



Patented Westin type tube forming machine, designed for combined heating and forming of tubes up to 10" diameter and as used for gas bottle production etc. The machine is used for forming both neck and base section to final requirements and includes automatic welding of base.

Apply for full Specifications and Literature to Dept. E.D.

British Federal
WELDER & MACHINE CO. LTD.

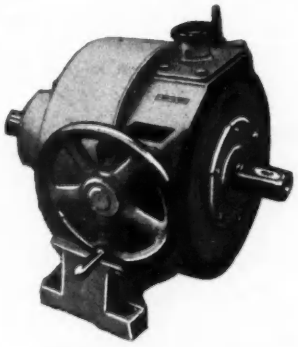
CASTLE MILL WORKS
DUDLEY WORCESTERSHIRE ENGLAND

TORQUE & SPEED CONTROL

The Ultimate in
Power Transmission . . .

VOITH/N.B.L.

VARIABLE RATIO



TORQUE CONVERTERS

The Converter with precise Control System giving the exact torque or speed as and when wanted.
Controllable through variable reaction blading and giving the D.C. series wound motor characteristics for use with the simplified A.C. constant speed motor.
Range of sizes from 20 H.P. to several thousand H.P. through one transmission.

NORTH BRITISH LOCOMOTIVE

CO. LTD., GLASGOW

LONDON OFFICE: LOCOMOTIVE HOUSE, BUCKINGHAM GATE, S.W.1

PRESSING

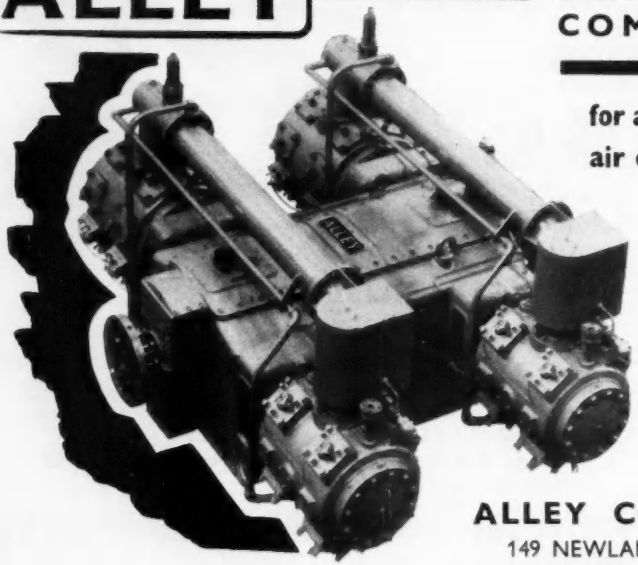
If you require pressings consult Ward (Metal Details) Ltd. We are specialists in the manufacture of all types of small and medium pressings of any shape, size and thickness, in steel, tinplate, copper etc. from which complete assemblies can be fabricated by welding, soldering or brazing.
Illustrated here are some examples of our products, and similar components can be produced to your own specification and design, and supplied in painted, plated or enamelled finishes.

WARD
(METAL DETAILS) LTD.

DARLASTON · STAFFS

ALLEY

BALANCED OPPOSED COMPRESSORS



for all industrial applications—air or gases

Combining the known advantages of the horizontally opposed design with Alley's long experience of high-class compressor manufacture, the Alley balanced opposed unit is an attractive proposition wherever compressed air is required.

Two, four and six-Crank units available up to 1,250 B.H.P

It is completely self-contained and totally enclosed; intercooler, oilcooler and motor are compactly built on. Being vibration-free it can be installed on minimum foundation, simply bolted down and is then ready to run.

ALLEY COMPRESSORS LTD.

149 NEWLANDS ROAD, GLASGOW, S.4

Phone: MERylee 7141 Grams: "Giweir Glasgow Telex"

A member of the **weir** Group of Companies

HERMETIC RUBBER PRODUCTIONS

To meet every need of Modern Industry in current production or future development.

Our many years of experience as manufacturers in Natural or Synthetic Rubber are at your disposal.

Moulded Products of all kinds, Flexible Fabric Couplings Discs, Extruded Rubber Sections, Radiator Hose (Canvas Inserted), Mud and Stone Deflectors, Mats and Matting.

Est. 1895

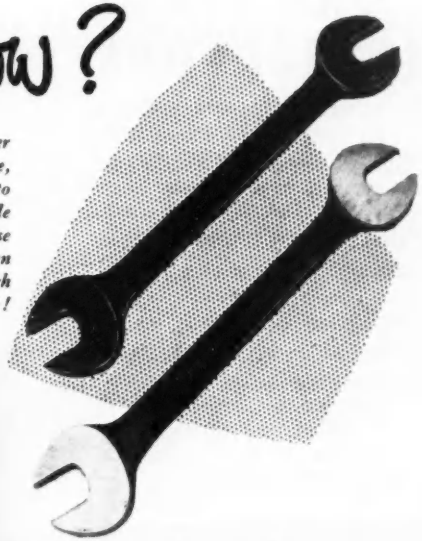
HERMETIC RUBBER CO. LTD.

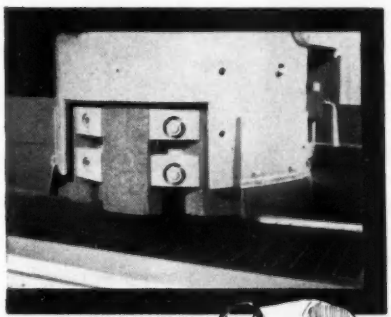
"Hermetic" Works, Priory Rd., Birmingham 6

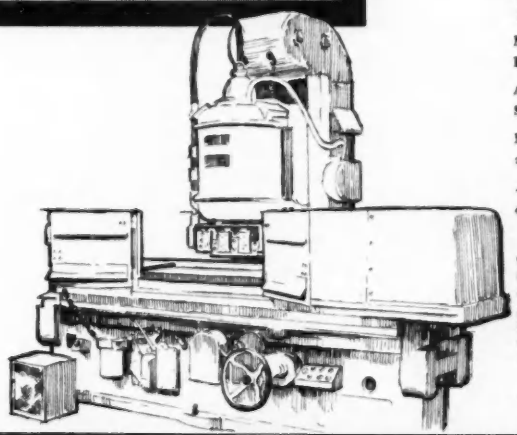
Telephone: East 3638/9
Grams: Hermetic, Birmingham

Do you know?

That you can get higher production with better finish at lower cost on vertical spindle, segmental surface grinding. By changing to ALOXITE vitrified segments, it was possible to reduce the abrasive cost of grinding these spanners by more than 5% – this is quite an item when you're grinding in quantities such as our customer does. And look at the finish!







Here are the production figures:

COMPONENT GROUND
Open-end spanners, 11" long × ⅞ and ¾ Whit.

MATERIAL
EN47 chrome vanadium alloy steel.

ABRASIVE
Segments AA46—J5—VL.

NUMBER GROUND
200 doz. spanners per set of 6 segments

ABRASIVE COST
4·35 pence per dozen.

•

CARBORUNDUM can help you to achieve this kind of production and economy. And not only on segmental grinding. Whatever your grinding process, whatever your problem, we have experts who can advise on the best and most efficient use of abrasive materials.
Write and ask for a representative to call.

•

ALOXITE is a registered trade mark of the Carborundum Company Limited.

BONDED
ABRASIVES
DIVISION

THE CARBORUNDUM COMPANY LTD
TRAFFORD PARK, MANCHESTER 17

Telephone TRAfford Park 2381 Telegrams CARBORUND, TELEX, MANCHESTER

THORP EQUIPMENT FOR THE GAS INDUSTRY

GAS FLOW INDICATORS

Direct Reading, variable aperture type, from 0 to 150 lb./sq. inch.

For all types of gases; can be calibrated to customers' requirements. Brass body, stoved black crinkle finish.

Cast Iron Body for Corrosive Gases.

Scale Plate in black crinkle, chrome or polished brass.

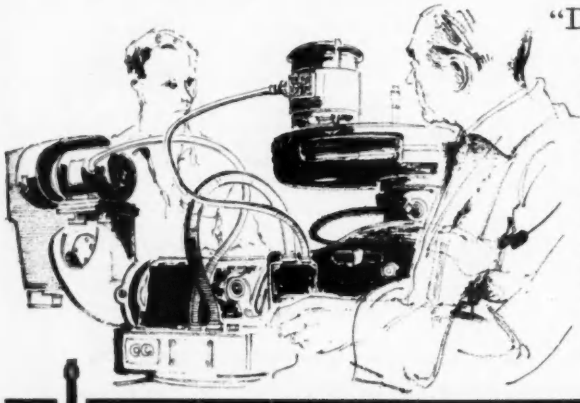
All Unions, etc., chrome plated.

Stainless Steel Float, in clear glass tube.

Customers when ordering should state—
(*a*) Specific Gravity and Working Pressure.
(*b*) Maximum and Minimum Rates of Flow.

Size B.S.P. ins.	Max. Capacity Cu. ft./Hr. Coal Gas @ 5/10" P.D.
¼	25
⅜	60
½	110
¾	230
1	420
1¼	650
1½	900
2	1600
2½	2500

THOMAS THORP & CO LTD
WHITEFIELD Manchester

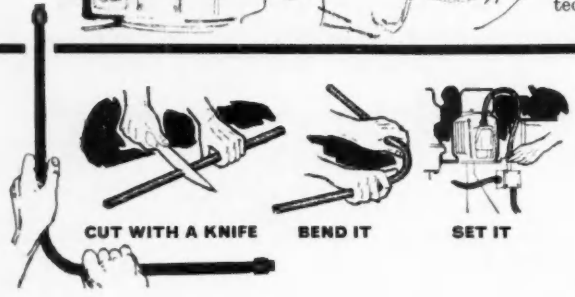


"Done already, Dick?"

"Yes . . . wiring doesn't take long with Kopex, you know. Ever seen it? Look. It's pliable. Just cut it, bend it and fix it. Marvellous."

Kopex Pliable Electrical Conduit. A significant advance in electrical wiring installations. Easily bent by hand, remains rigid after bending and can be shaped to any radius without distorting the bore. P.V.C. covered for protection against oil, corrosion and suds. Ideal for wiring machine tools and special purpose machinery in factories and chemical plants, etc.

Kopex couplings are made in a variety of metals, and can be used with any standard electrical fittings, to make a rigid, permanent joint. Full technical information and prices on request.



KOPEX

P.V.C. covered **PLIABLE ELECTRICAL CONDUIT**
(also available without P.V.C. covering)

UNI-TUBES LIMITED
Head Office: 197 Knightsbridge, London, S.W.7. Tel: KNightsbridge 7811/5
Works: Alpha Street, Slough, Bucks. Tel: SLough 25476/8

A member of SMITHS Group of Companies

WE ARE PROUD OF OUR ASSOCIATION WITH THESE FAMOUS CONCERNS

BRISTOL SIDDELEY ENGINES LTD
CARBODIES LTD
JOHN CURRAN LTD
DAIMLER COMPANY LTD
The DAVID BROWN Companies
FORD MOTOR COMPANY LTD
JAGUAR CARS LTD
THE PLESSEY CO LTD
ROVER CO LTD

From Design—to

Prototype—

We shape the things to come!

to Production work
in Sheet Metal and full Panel Assemblies

The Abbey Panel & Sheet Metal Co. Ltd.

A.I.D. A.R.B. AND C.I.A. APPROVED

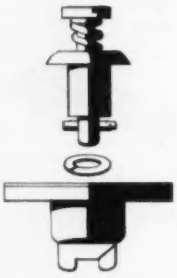
BAYTON ROAD · EXHALL · NR. COVENTRY · Tel: BEDWORTH 2071 P.B.X.

FASTEN/ATION

The mechanics of modern fastening have matured to the point where it is now considered a science.

We like to call it FASTEN/ATION.

Camloc has more than 20 years experience in this specialized field. The fastener shown is just one of many different types. (Write for catalog No. E 61)



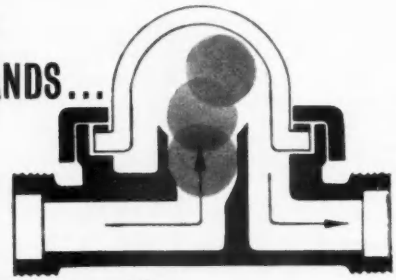
- ✱ fasten securely
- ✱ no loose parts
- ✱ quickly and easily installed
- ✱ open and close with a quarter-turn

(Technical Representative in Great Britain)

CAMLOC

CAMLOC FASTENER GMBH
Kelkheim/Taunus - Germany
Frankfurter Strasse 36
Tel: 288

LOOK NO GLANDS...



. . . no stuffing box either —in fact nothing to wear out at all!

This is the SHOFLO, the sight flow indicator that shows you whether or not liquid is flowing in a pipeline *even above eye level.* Simple and positive in operation, the SHOFLO prevents reverse flow, is ruggedly built with a toughened glass dome and easily withstands pressures of up to 100 p.s.i. Available in three sizes of ¼", 1" and 1½" bores, male or female connections—the ¼" size can be supplied with right angle inlet and outlet.
Write for brochure AB4/M17.

SHOFLO
Sight flow indicator

PARKINSON COWAN MEASUREMENT

P.O. Box No. 2, Dobcross, Oldham, Lancs · Tel: Delph 424

PCM17b

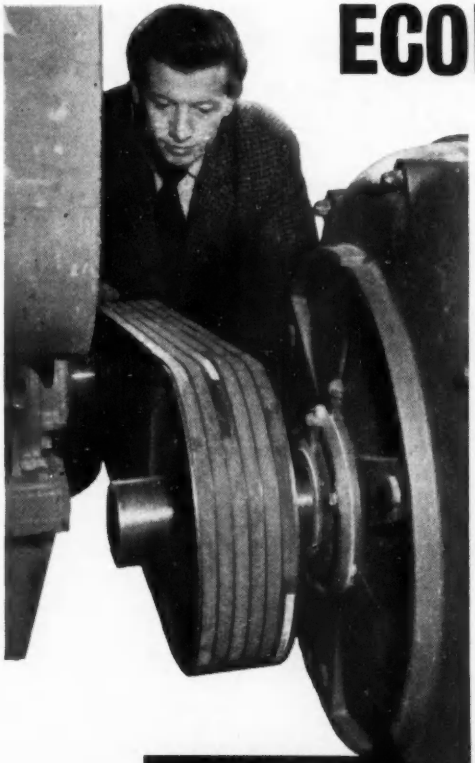
HERMETITE

The World's widest range of
JOINTING COMPOUNDS
is made by
KENILWORTH
pioneers and specialists in this field
HERMETITE
seals pressure tight!

For further information contact
THE KENILWORTH MFG. CO. LTD.
West Drayton · Middlesex
West Drayton 3731

CAPSTAN AUTOMATIC AND SPECIAL TURNED WORK
ALSO
FORGINGS AND PRESSINGS

ARMSTRONG STEVENS
& SON · LTD ·
POST BOX 2. 67-73 CONSTITUTION HILL.
BIRMINGHAM 19.



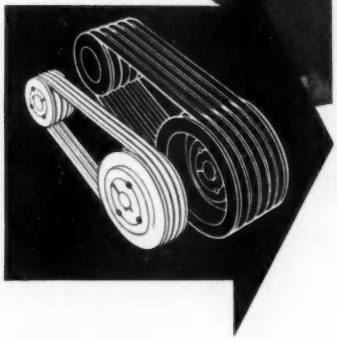
ECONOMY DRIVE?

save SPACE
save WEIGHT
save MONEY...

by fitting SpacesaVer Wedge-Belt Drives, the power-packed result of unceasing development. You can save TIME too, because standard SpacesaVer pulleys are fitted with ***Taper-Lock**** bushes for sure and rapid fixing. Expert staff in nineteen branch offices are available to help you with your power transmission problems.

Why not let them?
Power transmission is our business.

**Trade Mark*



Designed for the same duty, a SpacesaVer drive is slimmer, lighter, shorter and cheaper

SpacesaVer
WEDGE-BELT DRIVES

J · H · FENNER & CO · LTD · HULL

LARGEST MAKERS OF V-BELT DRIVES IN THE COMMONWEALTH

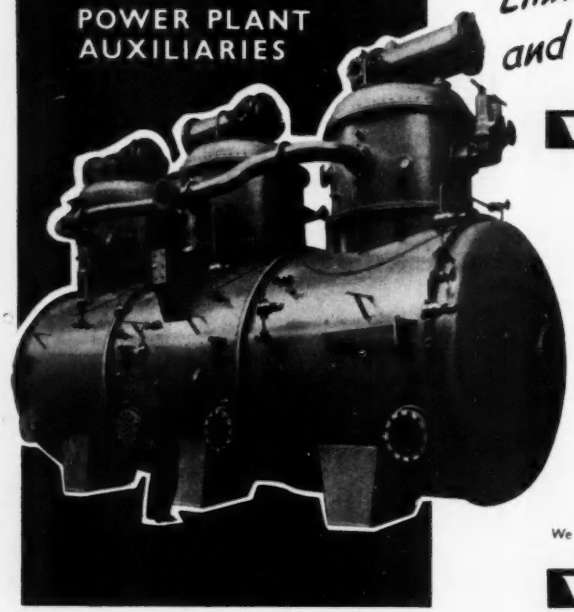
BRANCHES:
BELFAST · BIRMINGHAM · BRADFORD · BRISTOL · BURNLEY · CARDIFF · GLASGOW · HULL · LEEDS · LEICESTER
LIVERPOOL · LONDON · LUTON · MANCHESTER · MIDDLESBROUGH · NEWCASTLE · NOTTINGHAM · SHEFFIELD · STOKE

FACTORIES OVERSEAS IN AUSTRALIA, INDIA AND SOUTH AFRICA

H.F. 8791

Weir

POWER PLANT AUXILIARIES



Elimination of dissolved oxygen and CO_2 from boiler feed water

Weir DE-AERATORS

provide the most practical and efficient means of de-aerating boiler feed water by the simplest and cheapest method; no heat is lost, the process being one of heat exchange.

The Weir De-aerator prolongs the life of economiser tubes, boiler tubes, turbine blading, governor valves, steam valves, etc., in short, of the whole system.

The effect on the upkeep of boilers and fittings represents a saving which will repay the cost of a de-aerator in a short time.

The Weir Triple De-aerator illustrated handles 730,000 lb /hr. feed water at 207° F.; oxygen content of feed water after de-aeration does not exceed 0.005 c.cms. per litre.

WEIR AUXILIARIES INCLUDE:
REGENERATIVE CONDENSERS : FEED HEATERS
FEED PUMPS : FEED REGULATORS : EVAPORATORS
AIR EJECTORS, etc., etc.

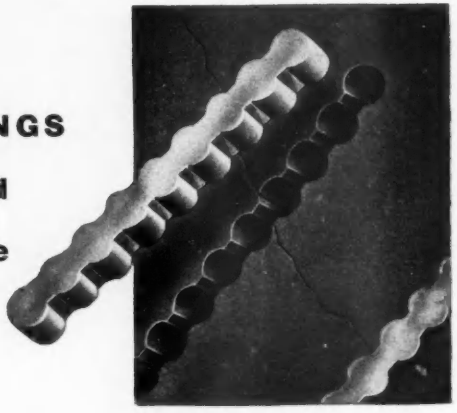
We invite enquiries for equipment to meet specified requirement

Weir G. & J. WEIR LTD.
CATHCART : GLASGOW, S.4

METALOCK

COLD REPAIRS TO CASTINGS

guaranteed repairs and immediate countrywide service on site — speedily at fractional cost



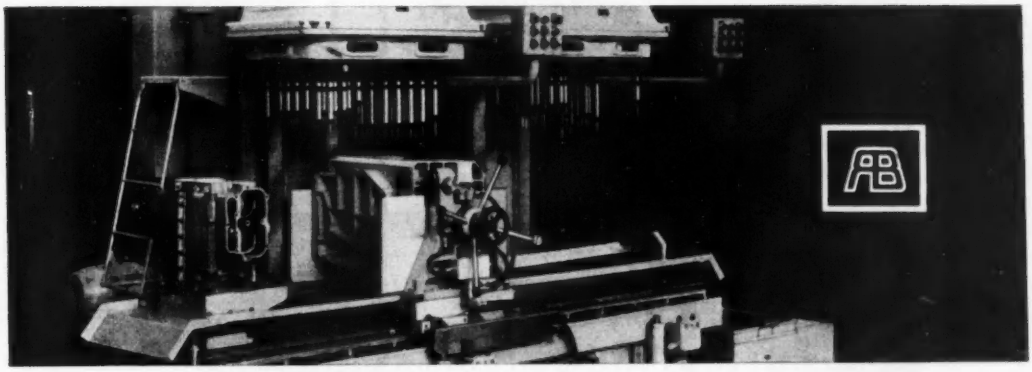
METALOCK (BRITAIN) LTD.

GRAND BUILDINGS, TRAFALGAR SQ., LONDON, W.C.2. tel: Whitehall 8902

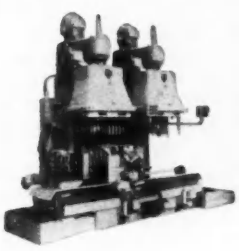
telephone area offices for service

BIRMINGHAM Bearwood 2799	**GLASGOW** City 7203	**NEWCASTLE** Newcastle 24808
BRISTOL Bristol 56014	**LIVERPOOL** Central 3820	**SHEFFIELD** Sheffield 29361
CARDIFF Cardiff 29719	**LONDON** Whitehall 8902-5	**WEST CUMBERLAND** Egremont 381

BERARDI



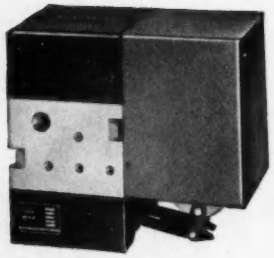
SHUTTLE TYPE MULTISPINDLE MACHINE VCM III SUITABLE FOR TAPPING



OPERATION ON THE CYLINDER BLOCK OF A NEW DESIGN PRIVATE CAR. SPINDLES TYPE CM WITH BUILT-IN LEAD SCREW, THE COMPONENTS ARE CLAMPED IN A FOUR STATIONS, HORIZONTALLY REVOLVING FIXTURE, ALLOWING THUS IN A SINGLE SET-UP THE MACHINING OF 4 SIDES. THAT IS 82 HOLES ALL TOGETHER.

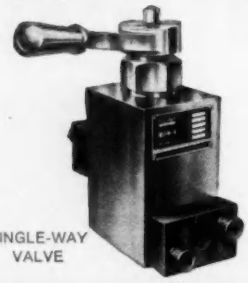
OFFICINE
RINO BERARDI
BRESCIA - ITALIA
VIA LAMARMORA 105
TEL. 53 352

Member of UCIMU

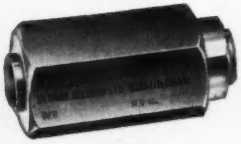


4-WAY E.C.II VALVE

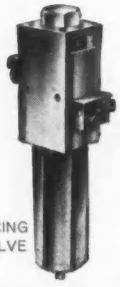
think of a valve



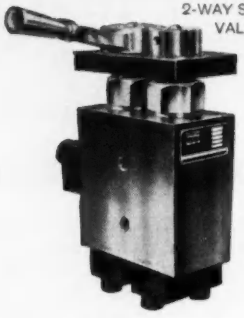
SINGLE-WAY VALVE



CHECK VALVE



REDUCING VALVE



2-WAY S.D. VALVE

. . . *any* valve for *any* circuit, using oil or water. You'll find it in the Ellison range. No valves are made with more precision or give longer life. They are supremely easy to maintain and completely safe under all conditions.

Ellison are *specialists* not only in making the finest valves you can buy but also in the design of complete hydraulic circuits. The range includes control valves, check valves (stepped connections and in line connections), relief valves, reducing valves, roller-operated single way valves, pilot-operated check valves and adjustable check valves.

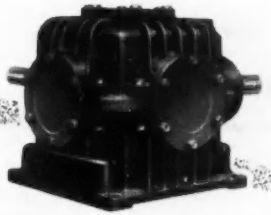
Our Engineers will be glad to give you further information and technical advice.

ELLISON HYDRAULICS

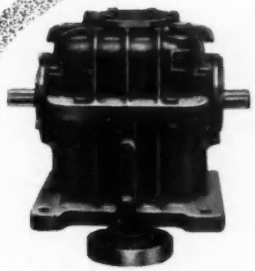
Division of George Ellison Limited
PERRY BARR · BIRMINGHAM 22B

105

SPIRAL OF FALLING COSTS



"RADIATION" HORIZONTAL UNIT



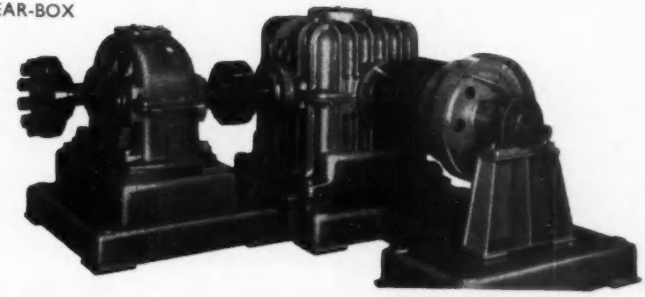
"RADIATION" VERTICAL UNIT

If you are watching costs you will do well to install Crofts "RADIATION" Spiral Bevel Gear Units. They are precision generated to give accurate and continuous tooth engagement; they lower noise levels, reduce maintenance and production costs, and ensure the optimum use of expensive power.

Available in both horizontal and vertical types, these units transmit powers from fractional to 1,100 h.p. and provide speed ratios from 1:1 to 5:1.

STANDARD SPIRAL BEVEL GEAR-BOX

For economical and most efficient power transmission, specify Crofts "RADIATION" Spiral Bevel Gear Units. (Full technical data available in our Publication 611.)



Paper Mill Drive comprising Single Helical Reduction Gear, Spiral Bevel Gear Unit and Airflex Clutch arranged with V-pulley. The complete drive mounted on combination baseplate, is of Crofts manufacture.

Crofts

CROFTS (ENGINEERS) LIMITED

POWER TRANSMISSION ENGINEERS

THORNBURY BRADFORD 3 YORKSHIRE Telephone: 65251 (20 lines)
Telegrams: "Crofters Bradford Telex" Telex 51186

Branch offices: *London* Belfast Birmingham* Bristol Cardiff Dublin Glasgow* Ipswich Leeds* Liverpool Manchester* Newcastle Northampton Nottingham Sheffield Stoke-on-Trent* ** Stockholding Branches*

Subsidiary Companies in Canada, South Africa, U.S.A.
World-wide Representation

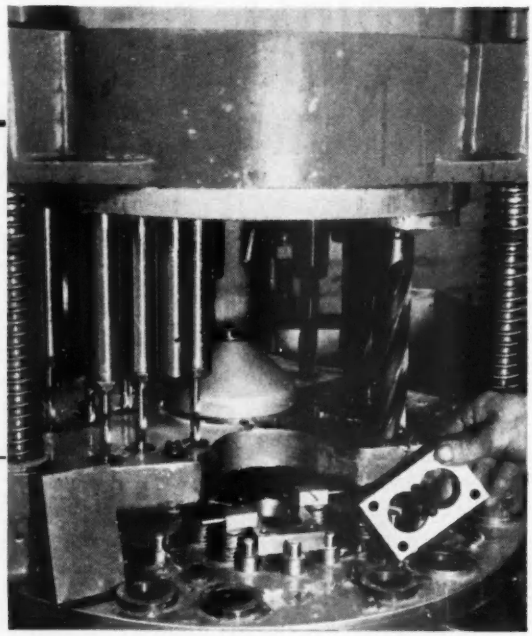
9 out of 11 minutes saved !

S.P.K. Fixed Centre Geared Multi-head fitted to 28in. Vertical Drilling machine using fixture fitted to standard S.P.K. Indexing Table.

Old time, using single spindle drills . . . . 11 mins. 29 secs.

New time, using S.P.K. equipment . . . . 2 mins. 5 secs.

Material—Martensitic Stainless Steel



Can we help you ?

SLACK & PARR Ltd.

KEGWORTH, Nr. DERBY

Telephone: Kegworth 306

With a complete range of dependable hoisting, loading and handling equipment, Aabacas offer you over forty-eight years' experience in the science of saving time, space and production costs.

AABACAS

***... first name in* ELECTRIC CRANES, TELPHERS & HOISTS**

Send now for complete reference catalogue to Sales Dept.,

AABACAS ENGINEERING CO. LTD. Head Office & Works: GRANGE RD., BIRKENHEAD. Telephone: 6673

London Office :
ST. MARTINS HOUSE, 29 LUDGATE HILL, E.C.4
Tel: CITy 7831-2

A1

Index of Current Advertisers and their Advertising Agents

Asbacas Engineering Co. Ltd. 164
Agency—Rowlinson Broughton Ltd.
Abbey Panel & Sheet Metal Co. Ltd. 157
Agency—Willington Adv. Ltd.
Acheson Colloids Ltd. ..... —
Agency—Norman Davis Ltd.
A.E.I.-Birlec Limited ..... —
Agency—Sandbrook, Metcalf & Co. Ltd.
A.E.I. Plastics (Aldridge) Ltd. ..... —
Agency—Taylor Advertising Ltd.
Allen, Edgar & Co. Ltd. ..... —
Agency—Rowlinson Broughton Ltd.
Allen, W. H., Sons & Co. Ltd. 78
Alley Compressors Ltd. 154
Agency—Scottish Industrial Advertising
Allspeeds Ltd. 35
Agency—Hyde & Partners Ltd.
Alumilite & Alzak Ltd. 12
Agency—Beresford Bourke Ltd.
Anderton Springs Ltd. ..... —
Agency—Powney Parker Publicity Ltd.
Angus, George, & Co. Ltd. 33
Agency—Redheads Adv. Ltd.
Archdale, James, & Co. Ltd. 52
Armco Ltd. 65
Agency—Industrial Publicity Service Ltd.
Armstrong Stevens & Son Ltd. 158
Agency—Boswell, Barratt & Phillips Ltd.
Associated Electrical Industries Ltd. ..... —
Agency—T.G.A. Co. Ltd.
Atlas Plating Works Ltd. ..... —
Agency—White & Carter Ltd.
Automotive Engineering Ltd. 138
Agency—T. B. M. Advertising Ltd.
Automotive Products Co. Ltd. 77
Agency—H. Raymond Morgan
Avo Ltd. ..... —
Agency—National Publicity Co. Ltd.

B.I.P. Engineering Co. Ltd. 17
Agency—Central News Ltd.
B.R.C. Engineering Co. Ltd. ..... Cover 3
Agency—Murray Watson Ltd.
B.S.A. Tools Ltd ..... Cover 4
Bailey, Sir W. H., & Co. Ltd. ..... —
Agency—T.G.A. Ltd.
Baker, John, & Bessemer Ltd. ..... —
Agency—J. Peers & Associates Ltd.
Balfour, Arthur, & Co. Ltd. ..... 6 & 7
Agency—Charles Stanley & Partners Ltd.
Bellows Valvair Ltd. 34
Agency—Elliott Advertising Ltd.
Benton & Stone Ltd. ..... —
Agency—Longleys & Hoffmann Ltd.
Berardi, Rino 161
Birfield Group ..... —
Birwelco Ltd. ..... —
Agency—Grosvenor Advertising Ltd.
Borg & Beck Co. Ltd. ..... —
Agency—H. Raymond Morgan
Brayshaw Tools Ltd. ..... —
Agency—Ingham Butterworth Ltd.
British Electric Resistance Co. Ltd. 130
Agency—John Collings & Partners Ltd.
British Federal Welder & Machine Co. Ltd. 152
Agency—Press and General Publicity Service Ltd.
British Manzel Oil Pump Co. ..... —
British Resin Products Ltd. ..... —
Agency—T. G. Scott & Son Ltd.
British Rolling Mills Ltd. 37
Agency—Maurice G. Parker Ltd.
Brookhirst Igranic Ltd 13
Agency—Stanley D. Dickson
Broom & Wade Ltd. 141
Agency—Stephens Adv. Service Ltd.
Brotherhood, Peter, Ltd. ..... —
Agency—J. Peers & Assocs. Ltd.
Brown, Boveri & Co. Ltd. ..... —
Brown, David, Corporation (Sales) Ltd. 1
Agency—Oelrichs Advertising Ltd.
Brown Fintube (Great Britain) Ltd. ..... —
Agency—Grosvenor Advertising Ltd.
Buhler Brothers (England) Ltd. ..... —
Bull, John, Rubber Co. Ltd. ..... —
Agency—Frank Gayton Adv. Ltd.
Butterley Co. Ltd., The 139
Agency—Rowlinson-Broughton Ltd.
Camloc Fastener GMBH 158
Agency—Batten Barton, Durstine & Osborn GMBH

Coppier, Fratelli 146
Carborundum Company Ltd., The 155
Carobronze Ltd. ..... —
Castrol Industrial Ltd. 2
Agency—Dorland Adv. Ltd.
Chapman & Hall Ltd. 14
Chesterfield Tube Co. Ltd. 36
Agency—C. B. Casson Ltd.
Churchill Machine Tool Co. Ltd., The ..... —
Agency—Associated British Machine Tool Makers Ltd.
Clayton-Wright, Howard Ltd. 66
Agency—Don Earl Publicity Ltd.
Colt Ventilation Ltd. 76
Agency—Greenlys Ltd.
Compoflex Ltd. 140
Agency—T.G.A. Co. Ltd.
Cory Bros. & Co. Ltd. ..... —
Agency—Hyde & Partners Ltd.
Cossor Ltd., A. C. ..... 114 & 115
Agency—Holmwood Advertising Ltd.
Coulthard, Wm., & Company Ltd. 60
Cradley Boiler Co. Ltd. ..... —
Agency—Riley Advertising Ltd.
Croda Ltd. ..... —
Agency—Farmer-Herbert Advertising Ltd.
Crofts (Engineers) Ltd. 163
Cronite Foundry Co. Ltd., The ..... —
Crowthorn Engineering Co. Ltd. 42
Agency—J. K. Clayton Advertising Ltd.

Dick, R. & J., Ltd. ..... —
Agency—Rex Publicity Ltd.
Doncaster, Daniel & Sons Ltd. ..... —
Agency—Rowlinson Broughton Ltd.
Dowty Seals Ltd. 51
Agency—Hamill Toms Ltd.

Eagle Pencil Co. 22
Agency—Saward Baker & Co. Ltd.
Electrical Development Association 116
Agency—Mather & Crowther Ltd.
Efco Furnaces Ltd. ..... —
Agency—Nigel Rainbow & Partners Ltd.
Electrical Power Engineering Co. (B'ham). Ltd. 74
Agency—Nicholls, Dorrity Advertising Ltd.
Elliott, B. (Machinery) Ltd. ..... —
Agency—Nigel Rainbow & Partners Ltd.
Elliott, E., Ltd. 23
Agency—Sterling Advertising Ltd.
Ellison, Geo. Ltd. 162
Agency—Crossley & Co. Ltd.
Empyrium Welding & Mfg. Co. Ltd. ..... —
Agency—Jack White & Assocs. Ltd.
Engineering Materials & Design Exhibition 72
Agency—F. John Roe Ltd.
English Electric Co. Ltd., The 47
Agency—Technical Advertising Service Ltd.
English Steel Tool Corporation 54
Agency—T.G.A. Ltd.
E.N.V. Engineering Co. Ltd. ..... —
Agency—Allardyce Palmer Ltd.
Evertaut Ltd. ..... —
Agency—Elliott Adv. Ltd.

Fabbrica Italiana Trapani Ideal ..... —
Fafnir Bearing Co. ..... —
Agency—H. Raymond Morgan
Faure Herman ..... —
Fel-Electric Ltd. ..... —
Agency—Oelrichs Advertising Ltd.
Fenner, J. H., & Co. Ltd. 159
Agency—Hyde & Partners Ltd.
Fibreglass Ltd. ..... —
Agency—Notley Advertising Ltd.
Firth-Derihon Stampings Ltd., The ..... —
Agency—Stanley D. Dickson
Firth, Thos. & John Brown Ltd. ..... —
Agency—Stanley D. Dickson
Ford Motor Co. Ltd. 57
Agency—London Press Exchange Ltd.

Forgings & Presswork Ltd. 84
Agency—Central News Ltd.
Fraser, Andrew & Co. Ltd. ..... Cover 2
Agency—J. Peers and Associates Ltd.

Goodyear Tyre & Rubber Co. (G.B.) Ltd. 86
Agency—Erwin Wasey, Ruthrauff & Ryar, Ltd.
Gear Grinding Co. Ltd. ..... —
Agency—Sandbrook, Metcalf & Co. Ltd.
General Electric Co. Ltd. ..... —
Agency—Greenlys Ltd.
Glacier Metal Co. Ltd. ..... —
Agency—Bean Adv. Ltd.
Gloucester Foundry Ltd. ..... —
Agency—Print for Industry Ltd.
Griffiths, Gilbart, Lloyd & Co. Ltd. 144
Agency—Nicholls, Dorrity Advertising Ltd.

H.M.C. Wheels Ltd. 16
Agency—Brandis Davis Agency Ltd.
Hackbridge & Hewittic Electric Co. Ltd. 38
Agency—Industrial Publicity Service Ltd.
Hadfields Ltd. 58
Hall & Hall Ltd. ..... —
Agency—J. Peers & Associates Ltd.
Hallmac Tools Ltd ..... 4 & 5
Agency—Jack White & Associates
Hancock & Co. (Engineers) Ltd. 55
Agency—Tibbenham Publicity Ltd.
Hardy Spicer Ltd. 75
Agency—Central News Ltd.
Heap, Joshua, & Co. Ltd. ..... —
Heenan & Froude Ltd. 40
Agency—Murray Watson Ltd.
Hermetic Rubber Co. Ltd. 154
Hoffmann, Mfg. Co. Ltd., The 68
Holden, Arthur, & Sons Ltd. 150
Agency—S. D. Toon & Heath Ltd.
Holroyd, John, & Co. Ltd. 67
Agency—C. R. Casson Ltd.
Holroyd, John, & Co. Ltd. ..... —
Agency—Ripley, Preston & Co. Ltd.
Hydraulics & Pneumatics Ltd. ..... —
Agency—S. C. Peacock (Birmingham) Ltd.

I.C.I. (Plastics) Ltd. ..... —
Agency—S. H. Benson
Imperial Aluminium Co. Ltd. ..... —
Agency—Service Advertising Co. Ltd.
Imperial Chemical Industries Ltd. 145
Agency—Everetts Ltd.
Impero Internazionale ..... —
Industrial Diamond Information Bureau 132
Agency—Intam Ltd.
Industrial Fan & Heater Co. Ltd. 69
Agency—Sinclair Advertising Ltd.
Intermic Limited ..... —
Agency—Sandbrook, Metcalf & Co. Ltd.
International Meehanite Co. Ltd., The ..... —
International Nickel Co. (Mond) Ltd. ..... —
Agency—T.G.A. Co. Ltd.
Ionic Plating Co. Ltd. ..... —
Agency—A. A. Black Ltd.
Isopad Ltd. ..... —
Agency—E. W. Barney Ltd.

Jacobs Mfg. Co. Ltd. 118
Agency—Crane Publicity Ltd.
Jenkins, Robert, & Co. Ltd. 59
Agency—W. Hopwood & Co. Ltd.
Johnson Foster, H., Ltd. ..... —
Agency—Pickersgill Publicity Service Ltd.

Sparking time: $3\frac{1}{2}$ hours

THIS PEDAL PAD FORGING DIE took $3\frac{1}{2}$ hours to make on the new GKN Spark Machine, Model B1. How long would it have taken by other methods?

When you've worked it out, consider the GKN Spark Machine. *It is faster, more accurate, more versatile, more compact and better designed than any other machine of its kind*, yet both installation and running costs are low.

The GKN Spark Machine was designed by the GKN Group Research Laboratory. Not only is it backed by all the Laboratory's technical resources, but *every user of the GKN spark machine can count on regular visits from the makers' technical representative to ensure that he gets the most from his machine.*

Whether you are engaged in forging, wire-drawing or press-tool making, the GKN Spark Machine is something it will pay you to know about. Ask our sales agents for an illustrated brochure on the GKN Spark Machine (Models B1 & B2). Ask them now.

The GKN Spark Machine

DESIGNED BY THE GKN GROUP RESEARCH LABORATORY

WELSH METAL INDUSTRIES LTD.,
Caerphilly, Glamorganshire.
Sales Agents U.K.
M. C. Layton Limited, Abbey Wharf,
Mount Pleasant, Alperton, Wembley, Middx.
Rudkin & Riley Limited,
Cyprus Road, Aylestone, Leicester.
Alfred Herbert Ltd., P.O. Box 18,
Red Lane Works, Coventry.

A MEMBER OF THE GKN GROUP OF COMPANIES

Index *(continued)*

Kayser, Ellison, & Co. Ltd. —
Keelavite Hydraulics Ltd. 63
Agency—Cogent Advertising Service Ltd.
Kendall & Gent Ltd. 46
Agency—Associated British Machine Tool Makers Ltd.
Kenilworth Mfg. Co. Ltd. 158
Agency—Crossley & Co. Ltd
Kenyon, William & Sons (Power Transmission) Ltd. —
Agency—Bayard Publicity Ltd

Lancashire Dynamo & Crypto Ltd. —
Agency—Technical Designs Ltd.
Lancers Machinery Ltd. —
Agency—A.T.A. Advertising Ltd.
Lang Pneumatic Ltd. 53
Agency—J. Peers and Associates Ltd.
Laycock Engineering Ltd. —
Agency—Central News Ltd.
Ley's Malleable Castings Co. Ltd —
Agency—H. Raymond Morgan
Livet 152
Agency—O.C.E.R.P.
Lodge Plugs Ltd. 130
Agency—Elliott Advertising Ltd.
London Shafting & Pulley Co. Ltd. 30
Agency—Nigel Rainbow & Partners Ltd.
Long Meadow Felt Co. Ltd 21
Agency—Severn Publicity Ltd.
Low Moor Alloy Steelworks Ltd 73
Agency—Powney Parker Publicity Services Ltd.

Mercedes-Benz —
Agency—Heumann Werbegesellschaft G.m.b.H.
Mercer, Thos. (Air Gauges), Ltd. 61
Agency—Nigel Rainbow & Partners Ltd.
Metal Sections Ltd. 27
Agency—Sandbrook, Metcalf & Co. Ltd.
Metalock (Britain) Ltd. 160
Microtecnica —
Midgley & Sutcliffe Ltd. 151
Agency—Monarch Adv. Co. Ltd.
Midland Industries Ltd. —
Agency—A. A. Black Ltd.
Midland Pneumatic Ltd. 142
Agency—Sterling Advertising Ltd.
Midland Silicones Ltd. 70 & 88
Agency—Roles & Parker Ltd.
Mill Societa Generale delle Macchine 44
Mirrlees, Bickerton & Day Ltd. 41
Agency—Rowlinson-Broughton Ltd.
Mobil Oil Co. Ltd. 120
Agency—Masius & Fergusson Ltd.
Monks & Crane Ltd. Cover 1
Agency—Sandbrook, Metcalf & Co. Ltd.
Mono Pumps Ltd. —
Agency—Ripley, Preston & Co. Ltd.
Moore & Wright (Sheffield) Ltd. —
Morgan Crucible Co. Ltd., The 168
Mountford, Fdk., Ltd. 150
Agency—S. D. Toon & Heath Ltd.

Neill, James, & Co. (Sheffield) Ltd. 15
Agency—J. K. Clayton Adv. Agency Ltd.
Newall Group Sales Ltd. —
Agency—J. Peers and Associates Ltd.
Nitralloy Ltd. —
Agency—Stanley D. Dickson
North British Locomotive Co. Ltd. 153
Agency—Scottish Industrial Advertising

Officine Meccaniche Fratelli Camurri di Nemesio-Rolo (R.E.) 142
Ormond Engineering Co. Ltd. 20
Agency—J. Manser Atkins & Co. Ltd.
Osborn, Samuel, & Co. Ltd. 19

P. R. Motors Ltd. 71
Agency—A. A. Black Ltd.
Parkinson Cowan Measurements 158
Agency—Roles & Parker Ltd.
Pergamon Press Ltd. 18
Perkins Gas Turbines Ltd. —
Agency—Crane Adv. Ltd.
Pickering, R. Y., & Co. Ltd. 43
Agency—Barbour MacLaren Advertising Ltd.
Pitman, Sir Isaac, & Sons Ltd. 3
Pollard Bearings Ltd. —
Agency—Hedley, Byrne & Co. Ltd.
Polypenco Ltd. —
Agency—Anthony Handley Adv. Ltd.
Precision Gear Machines & Tools Ltd 39
Agency—Apex Adv. Ltd.
Pyrene Co. Ltd., The 8
Agency—Nelson Adv. Service Ltd.

Ransome & Marles Bearing Co. Ltd. —
Agency—Ruddocks Advertising Agency
Renold Chains Ltd. —
Reynolds Tube Co. Ltd. 144
Agency—Ripley, Preston & Co. Ltd.
Richards, Charles, & Sons Ltd. —
Agency—Longleys & Hoffmann Ltd.
Richardsons Westgarth (Hartlepool) Ltd. —
Agency—Notley Advertising Ltd.
Rockweld Ltd. 79
Agency—John Mitchell & Partners Ltd.
Rockwell Machine Tool Co. Ltd. —
Agency—John Mitchell & Partners Ltd.
Rocol Ltd. —
Agency—Nevin D. Hirst (Advertising) Ltd.
Rovetta Baldo —
Royal Worcester Industrial Ceramics Ltd. —
Agency—Nevin D. Hirst (Advertising) Ltd.
Royce Electric Furnaces Ltd. 147
Agency—Nigel Rainbow & Partners
Ryder, Thos., & Son Ltd. 56
Agency—W. S. Crawford Ltd.

S.A.I.M.P. —
Salter, Geo., & Co. Ltd. —
Agency—Severn Publicity Ltd.
Sanderson, Bros., & Newbould Ltd. —
Sandvik Swedish Steels Ltd. —
Agency—Longleys & Hoffmann Ltd.
Saturn Industrial Gases Ltd. 9
Agency—Crossley & Co. Ltd.
Saunders-Roe Ltd. —
Agency—Stanley D. Dickson
Self-Changing Gears Ltd. —
Serck Radiators Ltd. —
Agency—Longleys & Hoffmann Ltd.
Sheffield Twist Drill & Steel Co. Ltd. 45
Siemens—Schuckert (Great Britain) Ltd. 69
Agency—Smee's Advertising Ltd.
Slack & Parr Ltd. 164
Agency—Rex Publicity Ltd.
Sleeper C.E. Ltd. 10
Agency—Dryden Allen Ltd.
Slip Products & Engineering Co. Ltd. 25
Agency—Mark Fawdry Ltd.
Smith, C. & B., Ltd. —
Agency—J.T.L. Advertising
Smith, S., & Sons (England) Ltd. 80
Agency—Masius & Fergusson Ltd.
Smith's Industrial Instruments Ltd. —
Agency—Allardyce Palmer Ltd.
Solex (Gauges) Ltd. —
Agency—David Macauley Adv. Ltd.
Spencer Wire Co. Ltd. 148
Agency—Divers Advertising
Steel, J. M., & Co. Ltd. —
Agency—Reynell & Son Ltd.
Sterling Metals Ltd. —
Agency—T. G. Scott & Son Ltd.
Stone, J., & Co. (Charlton) Ltd. —
Agency—Holman Adv. Ltd.
Stone-Wallwork Ltd. 134
Agency—Holman Advertising Ltd.
Stubs, Peter, Ltd. 10
Agency—Rowlinson-Broughton Ltd.
Super Oil Seals & Gaskets Ltd. 62
Agency—A. A. Black Ltd.
Sykes, W. E., Ltd. —
Agency—W. S. Crawford Ltd.

Teddington Aircraft Controls Ltd. —
Agency—Stanley D. Dickson
Tempered Spring Co. Ltd. 36
Agency—Stowe & Bowden Ltd.
Terrapin Ltd. 48 & 49
Agency—John Carr & Associates Ltd.
Terry, Herbert & Sons Ltd. 122
Agency—John Haddon & Co. Ltd.
Thorp, Thomas, & Co. Ltd. 156
Agency—J. Peers & Assoc. Ltd.
Torrington Co. Ltd., The —
Agency—Osborne Peacock Co. Ltd.
Tufnol Ltd. —
Agency—Crossley & Co. Ltd.
Turner Bros., Asbestos Co. Ltd. 136
Agency—Crane-Wood Ltd.

Unbrako Socket Screw Co. Ltd. 32
Agency—Nicholls, Dorrity Adv. Ltd.
United States Metallic Packing Co. Ltd. —
Agency—Wm. Furness Ltd.
Uni-Tubes Ltd. 156
Agency—Fredk. Aldridge Ltd.

Variatio-Strateline Gears Ltd. —
Agency—Thomas G. Birtles Ltd.
Varley, F. M. C., Ltd. 50
Agency—J. Peers & Associates Ltd.
Venesta Plywood Ltd. 148
Agency—Taylor Advertising Ltd.
Vickers Armstrong (Engineers) Ltd. 11
Agency—T.G.A. Ltd.
Vokes Ltd. 149
Agency—Trowbridge, Pritchard & Co. Ltd.

Walker, Crosweller & Co. Ltd. 124 & 128
Agency—Beardmore Advertising Ltd.
Walpamur Co. Ltd., The 143
Agency—Osborne-Peacock Co. Ltd.
Ward, H. W., & Co. Ltd. —
Agency—Associated British Machine Tool Makers Ltd.
Ward (Metal Details) Ltd. 153
Agency—Beardmore Advertising Ltd.
Weir, G. & J., Ltd. 160
Agency—Scottish Industrial Advertising
Wellman Bibby Co. Ltd., The —
Wellworthy Ltd. 113
Agency Riggs Advertising Ltd.
Welsh Metal Industries Ltd. 166
Agency—Notley Advertising Ltd.
Westool Ltd. —
Agency—Tibbenham Ltd.
Wharton Crane & Hoist Co. Ltd. 64
Agency—Henry Pybus Ltd.
White S.S. Dental Mfg. Co. (G.B.) Ltd. —
Whitehouse Industries Ltd. —
Agency—Hedley Byrne & Co. Ltd.
Wild-Barfield Electric Furnaces Ltd. —
Agency—Crane Publicity Ltd.
Wolverhampton Diecasting Co. Ltd., The 82
Agency—Sterling Advertising Ltd.
Wragby Plastics Ltd. 126
Agency—Wilsmore & Tibbenham Ltd.

Young, Joseph & Sons Ltd. 66
Agency—MacDonald Adv. Ltd.

It sticks out a mile!

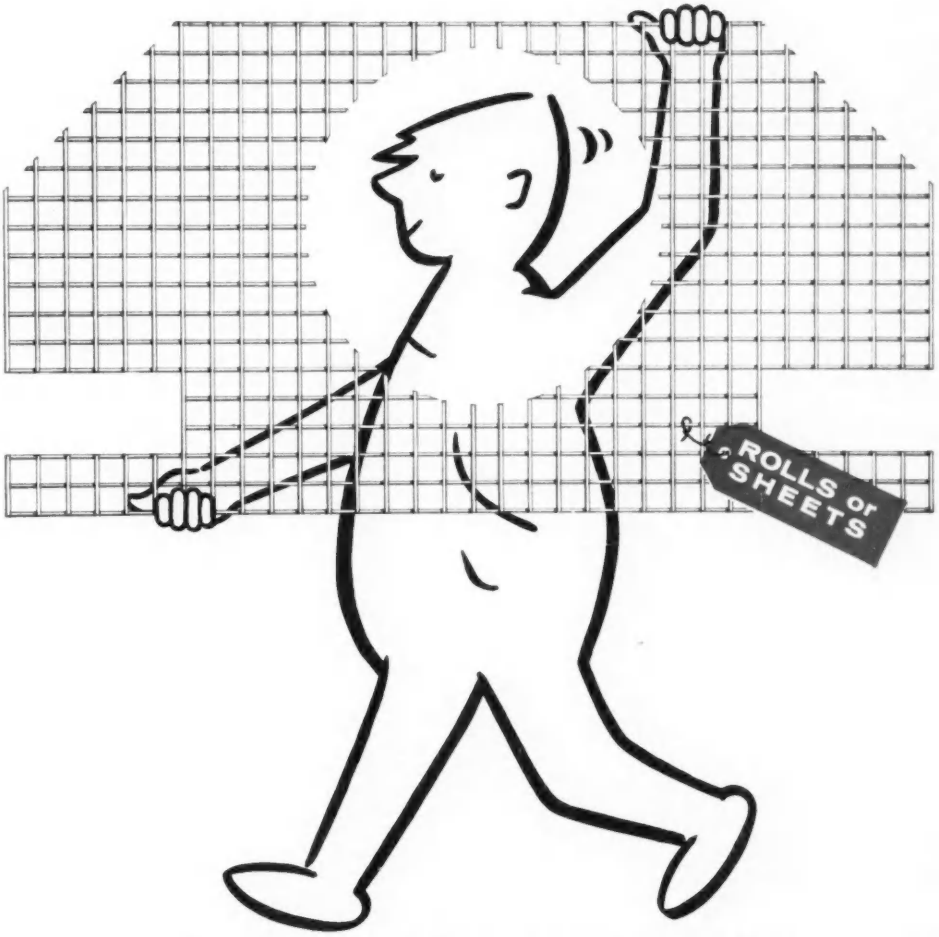
This is a carbon world—it sticks out a mile. Carbon in ships, carbon in trains, carbon in motor cars, carbon in aircraft; carbon in electrical generation; carbon in current collection; carbon in washing machines and vacuum cleaners; carbon in telephones, pumps, radios and refrigerators; atomic carbon, mechanical carbon, electrical carbon—always carbon is somewhere at work. In the last fifty years, we have put carbon on the map. We have adapted it to the needs of so many industries that now our MORGANITE carbon products are known throughout the world. Their quality, reliability and consistency are outstanding.

Morganite Carbon Limited

A Member of The Morgan Crucible Group.

BATTERSEA CHURCH ROAD
LONDON S.W.11
BATTERSEA 8822

C61A/706



here is a man on his way to solving his guarding problem with

Weldmesh

Regd. Trade Mark

He cut it to the shape he wanted—
it held together because it was welded together

Weldmesh is a registered trade mark and is supplied in rolls or sheets direct to the users by the sole manufacturers:

THE B.R.C. ENGINEERING COMPANY, STAFFORD

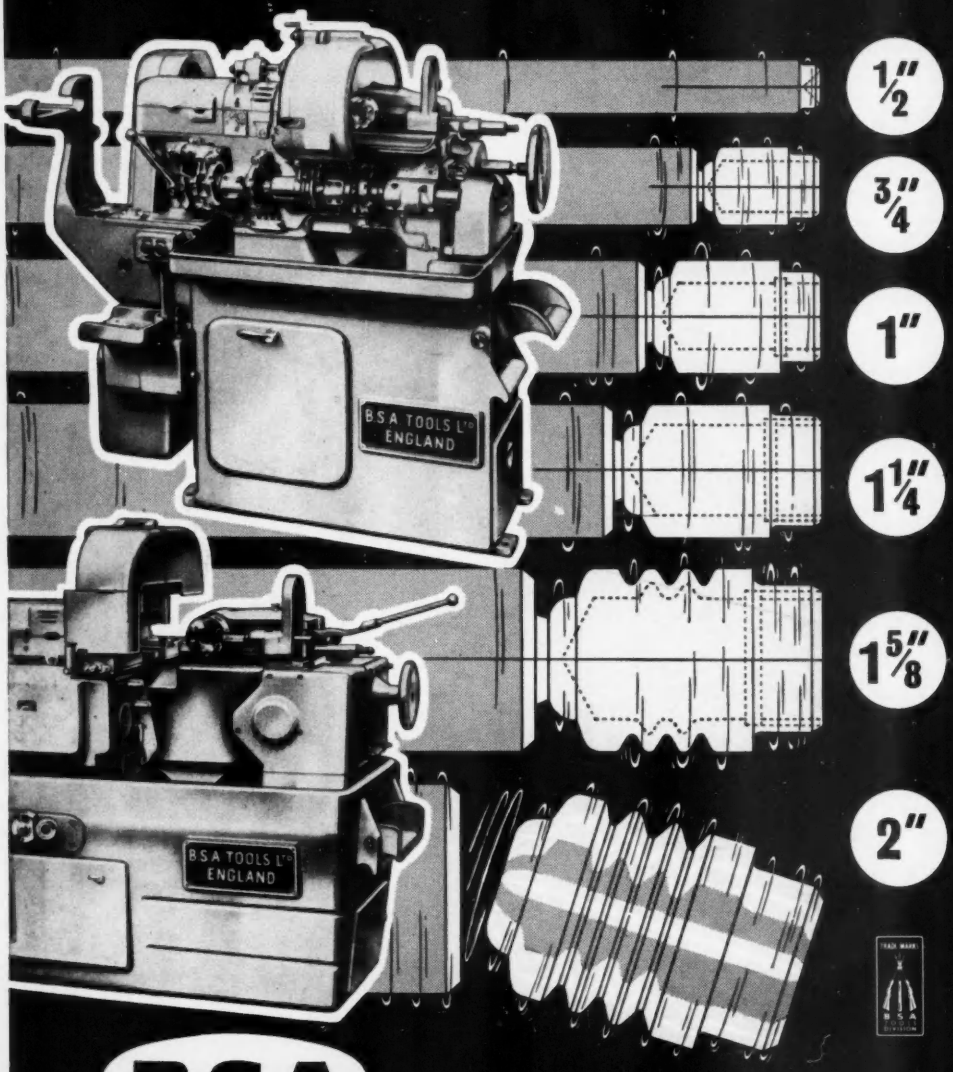
London, Birmingham, Bristol, Chelmsford, Leeds, Leicester, Liverpool, Manchester, Newcastle, Cardiff, Glasgow, Dublin, Belfast, Bulawayo, Calcutta, Johannesburg, Singapore, Vancouver.

Export Sales: 54 Grosvenor Street, London, W.1

M-W.1041

there are several variations of six basic types:

e.g. STANDARD · SIMPLIFIED · SHORT STROKE · LONG STROKE · INCH · METRIC · TWO SPEED · FOUR SPEED



B·S·A

prolific single spindles

B.S.A. TOOLS LTD · BIRMINGHAM 33 · ENGLAND

SOLE AGENTS GREAT BRITAIN · BURTON GRIFFITHS & CO. LIMITED · KITTS GREEN · BIRMINGHAM, · TEL. STECHFORD 3071 · TELEX 33-207